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ENGINEER

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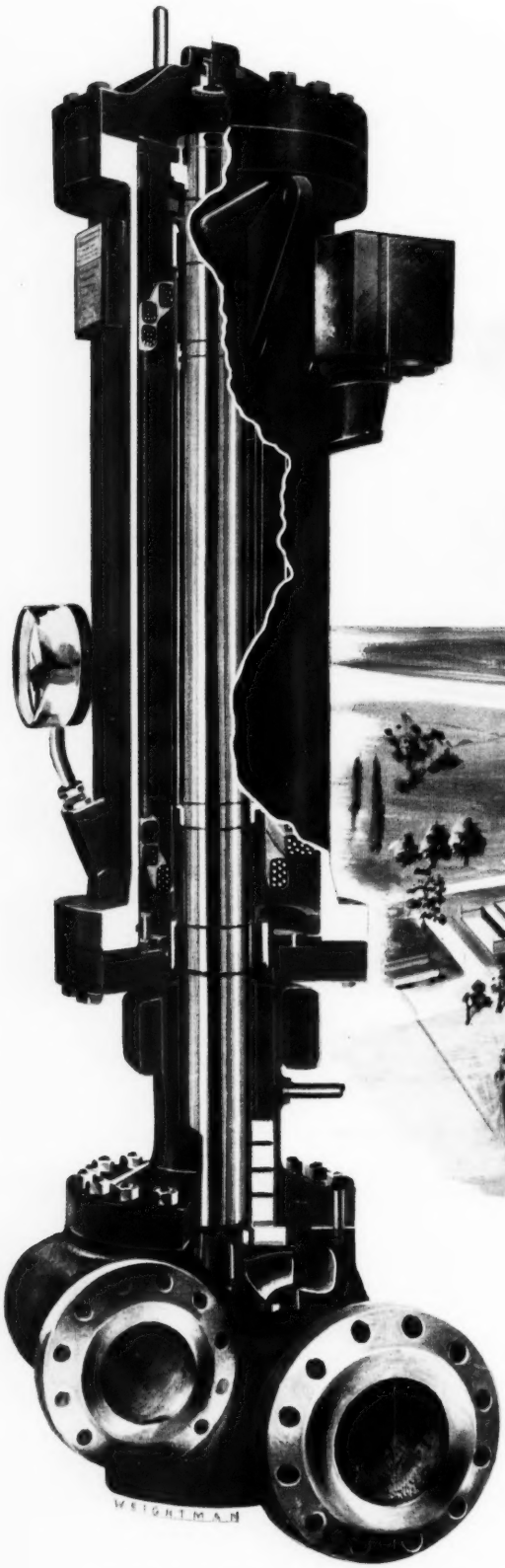

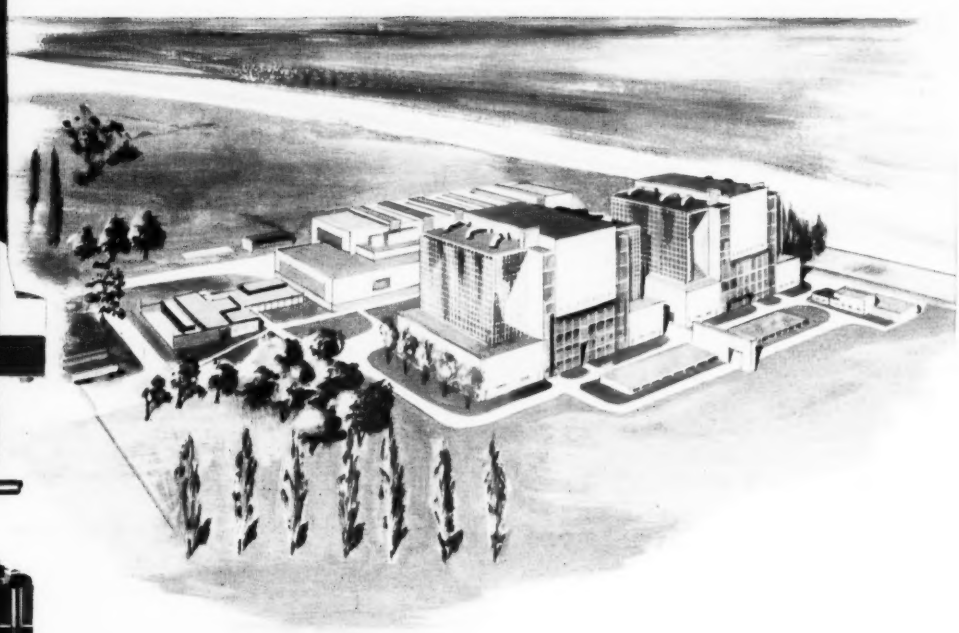

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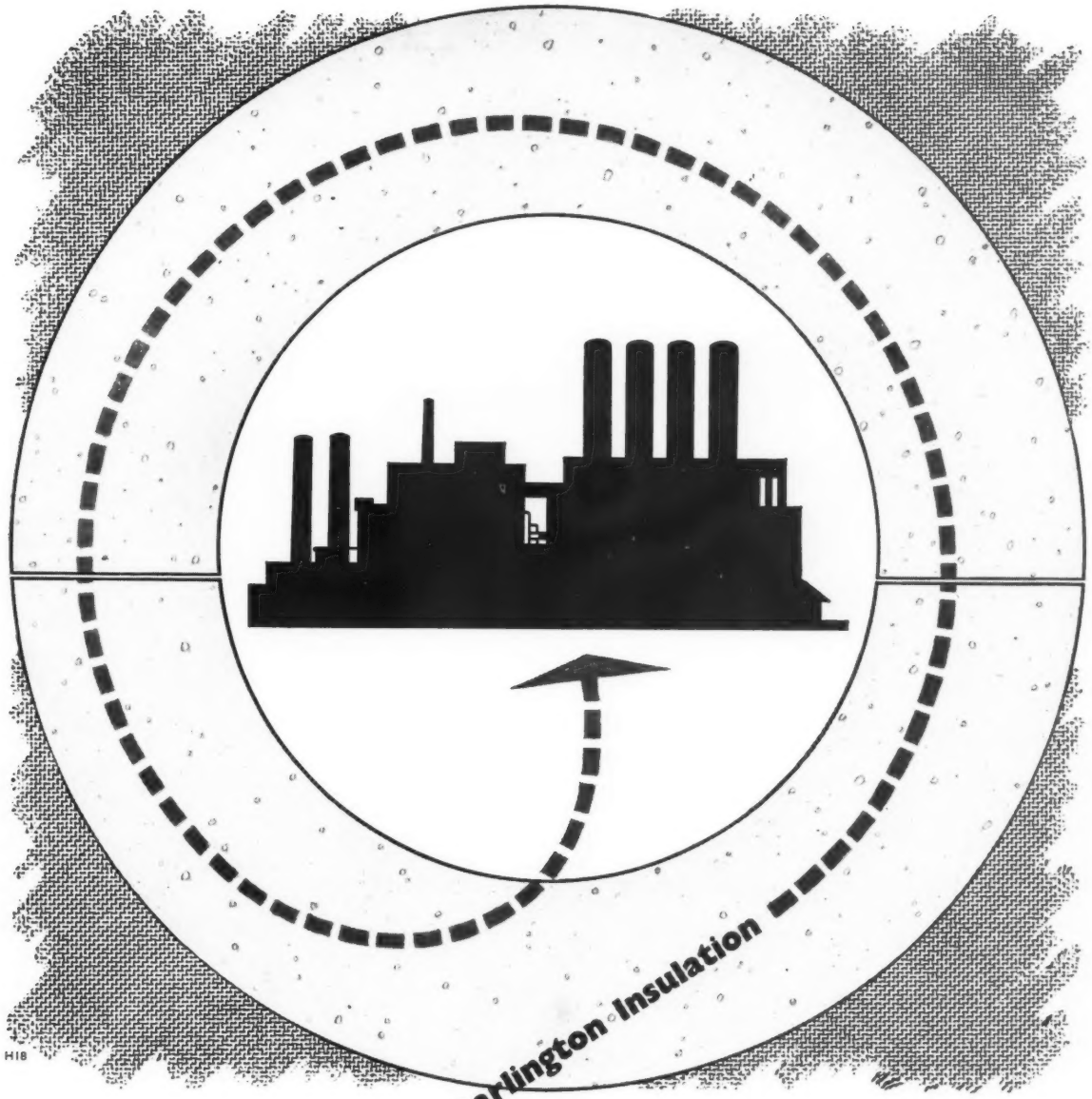

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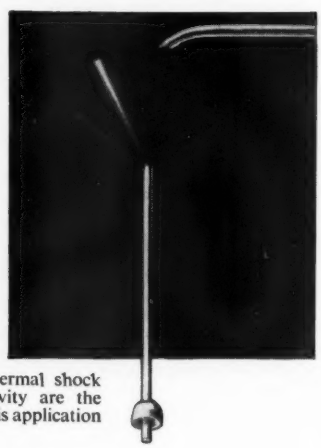

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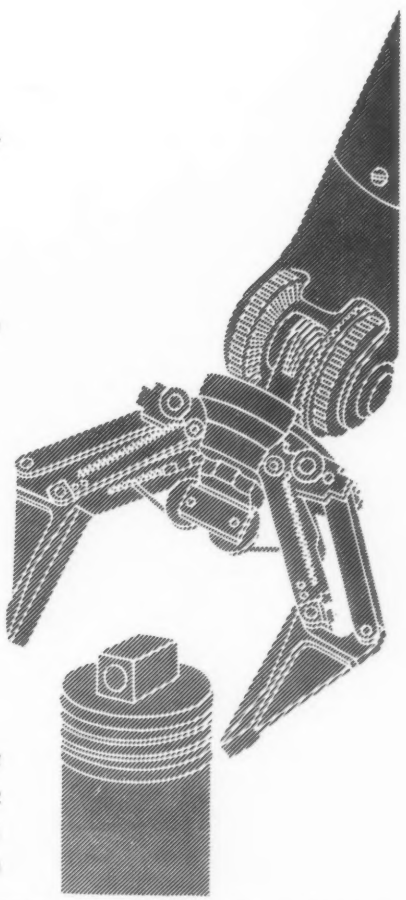

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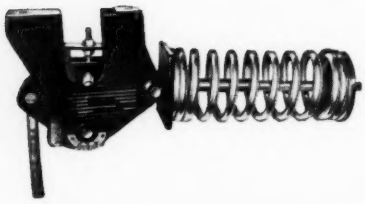

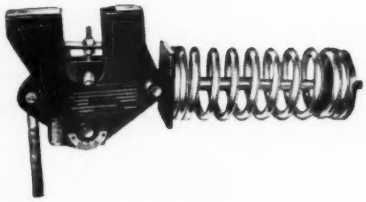

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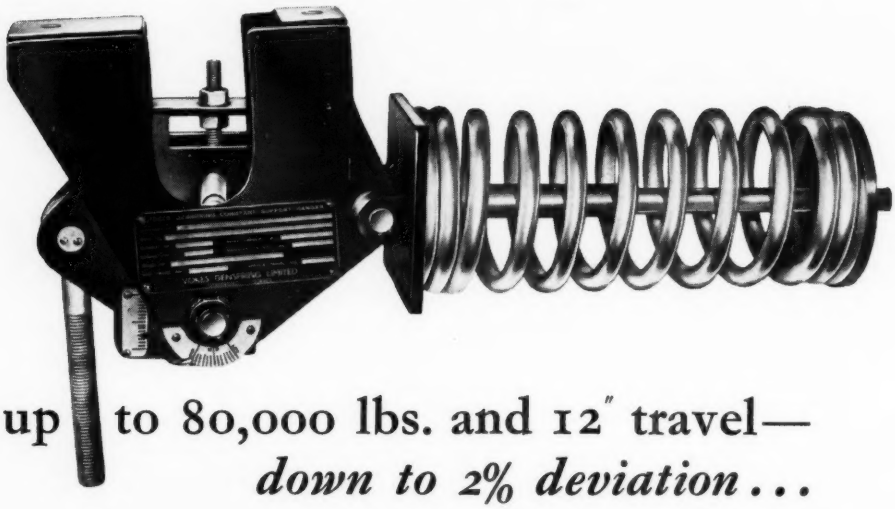

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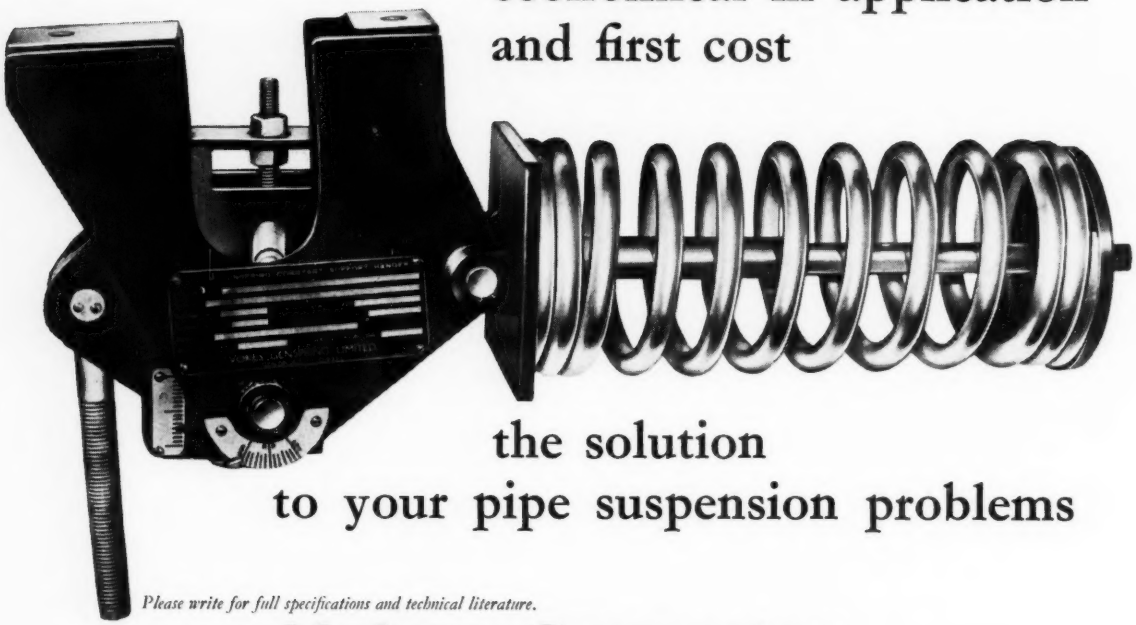

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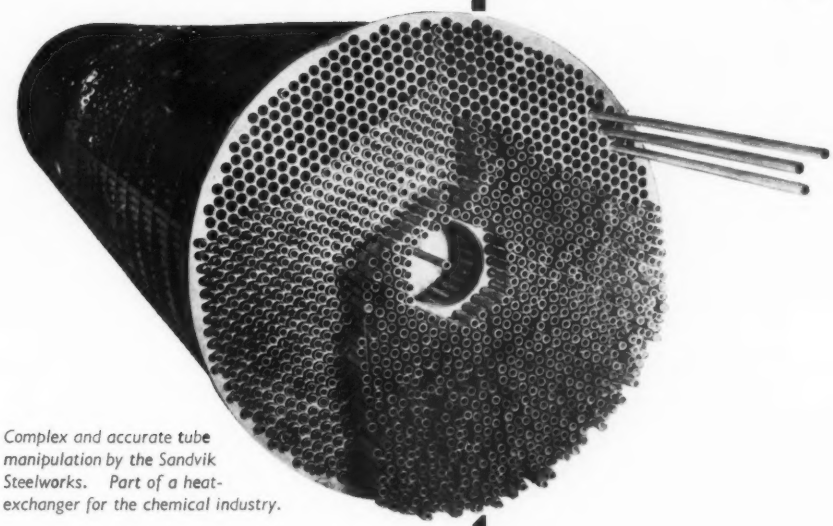

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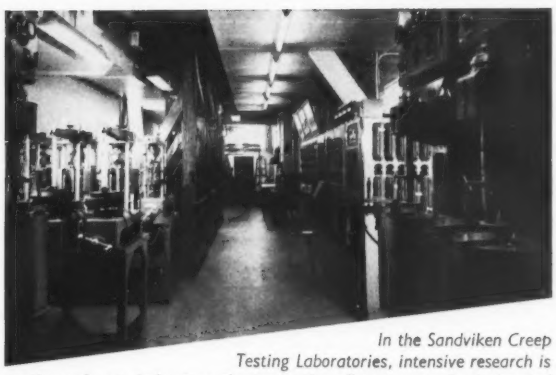

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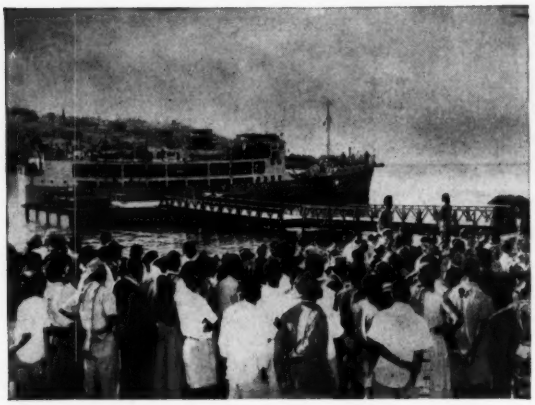

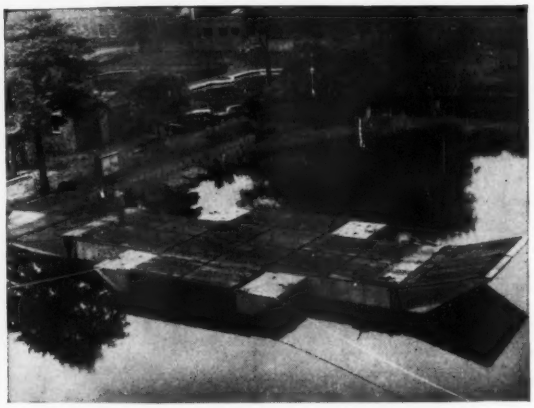

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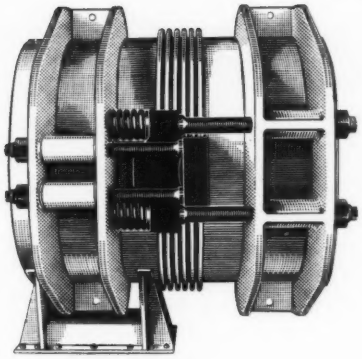

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The ACTIVE ANCILLARY BUILDINGS

PART II

by W. A. GILLINGHAM

The author, who is in the reactor department of W. S. Atkins and Partners, the Consulting Engineers, continues his description of the active ancillary buildings at Berkeley nuclear power station with an outline of the problems attached to the construction and use of the decontamination centre. He then goes on to discuss various available methods of dealing with radioactive effluents and how this problem is dealt with at Berkeley

(*Continued from page 253*)

IN the reactors radioactivity in liquid form is found in the sumps located in the boiler pit areas. Those that can be routed clear of the low level areas are taken out and discharged directly to a gravity drain system.

The basement sumps are allowed to reach the pump sump by a circumferential drain connecting the sumps beneath the boilers and then stainless steel pumps discharge the liquid at ground level to active drain. Part of the sump system is separated to enable active effluent (from the discharge chute sump) to be directed to the separate active drain line at ground level.

Dry down pipes are installed in the reactor services ducts with blanked off connections at all floors. In the event of it being necessary to isolate a floor of the reactor, temporary change rooms can be set up controlling the access to the floor services connected to the unit and the drainage conveyed away. Other radioactive liquids discharge either direct to gravity drain or via the basement sumps and are then pumped to a selected drain.

A Major Problem

The maintenance bay which constitutes a major problem in the reactor construction and requires special facilities, is located at the charge face floor in the reactor buildings. It is necessary to have this sort of room available for the decontamination and maintenance of the chute and charge machines, it being inadvisable to transport these machines to another centre.

The dismantling of these machines produces a hazard from airborne activity and an effluent from the decontamination liquors. Special facilities have to be provided for acid and alkali storage, detergent storage, ventilation, wash down routines. Special finishes to the walls and floors are required and can be similar to those already mentioned.

Provision should be made for vacuum cleaning to be carried out in the decontamination routines and toolboxes for dismantling the machines should be available. Spare parts are imported to the bay.

On the ventilation side it is estimated that during maintenance five changes an hour will be required with a warm air inlet. The air exhausting into the main stack via special filters. This maintains an inward airflow toward and through the " sealed " box.

Access is gained through a double door bay, the area between the doors forming a primitive clean area.

Cranes to be Used

At Berkeley it will be necessary to dismantle the chute machine at the charge face and then lower it through the roof hatch of the maintenance bay. Special handling routines will need to be worked out in order to accomplish this.

The reason for this method of handling is the length of the machine (50 ft). However, the charge machine can be lowered as a unit into the bay and can be dismantled piecemeal here.

To do all this, of course, craneage is essential and for part of the operation the 25-ton annexe crane is used and inside the bay a 10-ton hand-operated lifting block is used for lifting.

Personnel use the sub-change room for access to this bay and the charge face floor.

The decontamination centre is designed for the handling and decontamination of items such as hand tools, monitoring equipment, small laboratory equipment, possible protective suits, pump parts, crane hooks, etc. Large pieces of plant would not be brought to this unit ordinarily as these present problems of handling and transport, etc., across the site. It is expected that if and when necessary, *in situ* arrangements will be made for dismantling and decontaminating such equipment.

As decontamination is normally carried out by acid washes by scrubbing if necessary and then rinsing, perhaps neutralizing the acid first, the finishes and holding receptacles need to be of a corrosion resistant material. The building has storage and loading facilities, small and large decontamination tanks (I prefer these to be portable), and a " tanked " area for scrubbing the bigger pieces of equipment. The floor given here falls to a drainage sump, where the effluent can be sentenced.

The Monitor Room

A counting and monitor room may also be incorporated as a part of this unit and the instruments, of course, need protection against background activity and contamination.

The buildings should be well ventilated, the ventilation being capable of dealing with acid fumes as well as activity.

In my opinion benchwork again is best catered for by covering with PVC aprons, rather than build them with an impervious top integral with the furniture. Walls and ceiling are protected by strippable paint and built crevice free.

Because the floored areas need to be proof against abrasion and hard knocks, a tile of suitable strength is necessary. Class A engineering bricks with a suitable resistant cement joint and underlying impervious membrane afford good protection.

Services to this building are electricity, ventilation, water and drainage.

Treatment System

All the buildings dealt with in this article so far are located inside the reactor security fence but outside the active treatment area. Those that follow are inside this area Among them is the effluent treatment and carriage system.

There are three main sources of liquid effluent:—

(*a*) cooling pond water closed circuit;
(*b*) ablutions and laundry; and
(*c*) decontamination centres.

Because the degree of chemical and radioactive contamination varies in each of these effluents, for Berkeley it was agreed to separate them into three separate carriage systems. For want of better names they are called:—

(i) potentially active;
(ii) active (including decontamination); and
(iii) cooling pond circulation.

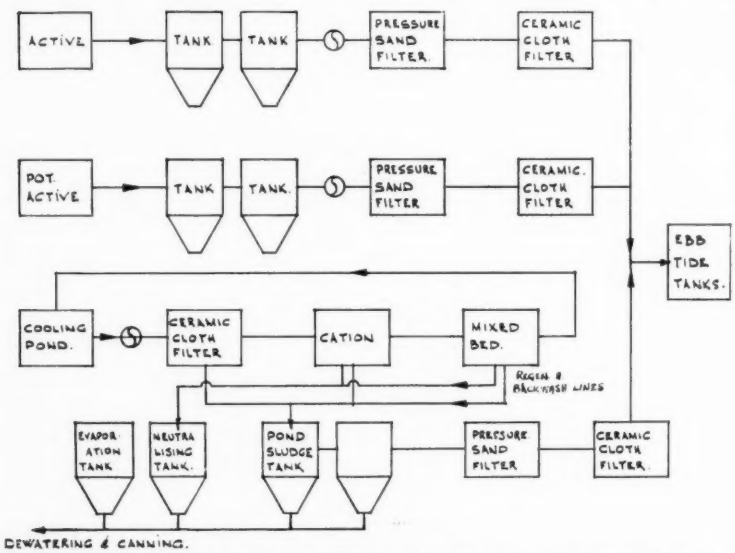
For future stations the separation may even go one further and isolate decontamination liquid from other active sources.

Any serious degree of contamination would be on clothing or articles, especially articles which had been used directly in fuel handling or conveyance. Hence a decontamination routine for these articles would strip the activity and provide a source of active effluent requiring specific treatment. These effluents will therefore be designated active and conveyed separately to the active holding tank.

The degree of contamination in effluents from the personnel ablutions and change rooms is expected to be negligible. Under certain circumstances however, it might well be desirable to discharge the effluent to the treatment plant and into the potentially active holding tanks.

Closed Circuit

As already mentioned the cooling pond water will constantly be scourged by passing it at a given rate through a so called "polishing plant" where contamination in the water is removed. The liquid remains in a closed circuit and is therefore returned to the pond. As the polishing plant is located in the treatment area, a third carriage system has had to be installed for conveying the liquid across the site.



Liquid effluents at Berkeley will be separated and treated according to their degree of chemical and radioactive contamination, and for this purpose three separate carriageways have been built to connect radioactive sources with the treatment plant. This flowsheet shows the various stages involved in the treatment of the different types of effluents, which for the sake of convenience are labelled "active," "potentially active" and "cooling pond effluent"

Routing Alternatives

Installation of these systems presented some problems. There are several ways of routing the pipes across a site:—

(*a*) on gantries carried above ground as pumped mains;

(*b*) through pumped mains in accessible ducts below ground level;

(*c*) in gravity drains buried but laid in such a manner as to be—(i) maintained and therefore accessible, and (ii) readily inspected for leakage.

Too Many Disadvantages

The merits and demerits of the several systems could be argued for many a day. Gantries were ruled out at Berkeley for several reasons. They would have had to be high to allow vehicular transit underneath. Special drip precautions and wind shielding would have been necessary. The structure would have required constant maintenance. Several holding and pumping stations around the site would have been needed. Gantries are ugly. Finally they have a high initial cost and the upkeep of the whole system would be expensive.

On the credit side gantries would give complete and easy access for inspection and maintenance. Also, there would be less problem in routing them across site in relation to other buried services. No excavation of trenches would be necessary and the treatment tanks could be above ground, although biological concrete might have been necessary.

An Ugly Solution

Pump mains in ducts seemed a better proposition. There were, however, the problems of access and there were many complications due to other services. Ground difficulties were also apparent. In addition, small holding tanks and pumping station local to sources of radioactivity would be required and the site would look ugly with access covers.

A gravity drain in access duct would virtually mean the duct becoming a tunnel at times, as final

inverts would be about 18 ft below surface level. This restricted crossover in other services.

The system adopted is based on the draw-pipe principle of having a container pipe of conduit set between draw manholes. The container pipe serves two purposes—first, as a second line protection against leakage into the ground and secondly, as a conveyance for any leakage to be transferred to the detector manholes.

The contained pipe needs to be flexible and elastic enough to revert to its original shape once installed. It should be corrosion resistant, and either easily decontaminable or inexpensive so that disposal could be considered. Maintenance should present no problems.

No Pumps Necessary

Because it is a gravity system, local holding tanks and pumps are not required. Also, it can be coordinated and routed fairly easily across site like any other service giving due consideration to its special features.

Excavation of trenches would normally be necessary and the holding tanks in the treatment plant would need to be deep in the ground. Allowance for these factors was taken into account and in the general design of the building.

Ordinary spun iron drain to British Standard with all-leaded joint has been chosen for the container pipes and the actual carriage drain in flanged polythene to BS 1973. As a second barrier the cast iron pipe is surrounded in dense mix concrete.

Special fittings were designed for the manhole junction and bends etc., and with the standard range kept in stock any section of the system can be changed or maintained without affecting operation of the station.

This latter is an essential feature of the systems and is affected at Berkeley by the installation of a spare container pipe which is kept plugged off until required.

The draw pipe is given an easy radius suitable for installing the polythene without causing it to collapse. Length by length the polythene is passed down from the surface along the draw pipe into the manhole and through the container pipe. Bolting and making good of the flanges are done in the manhole.

In order to aid drawing the pipes along, the distance between manholes never exceeds 100 ft and the leading pipe is fitted with a roller guide.

The pipe is supported along its length by polythene flanges welded to the pipe to prevent sagging and the flange is designed with nibs which keep the invert of the container pipe free to enable leakages to flow downstream to the manholes and detection pits. The design of the fittings at manholes make it possible to change from the service to the spare container in the event of a breakdown. Thus a defective section can quickly be isolated and dealt with at leisure, while the spare container becomes the service lane.

For example, a fault is discovered (by observation at the detector sump) between manholes A and B. A new length of carriage pipe installed in the spare container and the necessary fittings brought from store. It is short work to change the manhole connections on to the new route and the station is only inconvenienced for this short period. The pipe in need of repair is dealt with at leisure by withdrawing the lengths. Repairs are carried out *in situ* if it is found possible or at the workshop and the length restocked for future use. If necessary the whole defective length can be scrapped.

At the head of the system, building units connect to the drains, either as stainless steel pumping mains (from low level reactor boiler sump pits) or as polythene pipes serving the "plumbing" sources installed in the building.

Asbestos Replaces Iron

Inside buildings the same principle of drip carriage applies, although an asbestos half-round section is used instead of cast iron pipes.

The vertical stacks terminate as a vent in the normal manner as sufficient dispersal to the atmosphere is gained.

Wherever possible fittings and fixtures—such as gullies and drain points—inside buildings have been designed so that they can be removed and repaired. Where pipes pass through walls, sleeves are used. Where it is impossible then a stainless steel pipe or fittings are cast into concrete. Stainless steel fittings used underground elsewhere, on pumped lines for example, have the joints wrapped with a bitumenized strip.

At the downstream end of the carriage system, both the container pipe and the service pipe terminate in the respective holding tank at the treatment plant. Both the potentially active and the active carriage at Berkeley are to be constructed in this manner.

The cooling pond closed cycle system was a slightly different problem, arising from one source and having to be pumped initially from the ponds in any case. Here the pumping heads are utilized and the pumped mains, including the rising main for emptying the cooling ponds, will be installed in a shallow duct fitted with covers.

The routing of this duct was less difficult than in the case of the active and potentially active drains.

Possible Disposal Methods

Before considering the treatment plant at Berkeley which was designed by the AEI-John Thompson Co., Ltd., it will be as well to consider the methods which could be adopted for the disposal of a radioactive effluent. These are broadly:—

(1) natural decay;
(2) dilution and dispersion;
(3) land or sea burial; and
(4) concentration and storage.

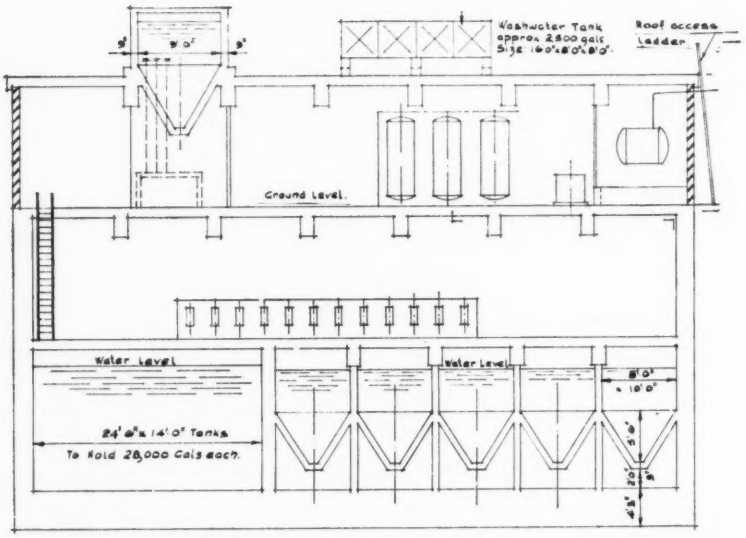
For a project such as a nuclear power station the prime factor to be taken into account is obviously safety of operation and therefore certainty of treatment within given limits. This needs to be allied with the fact of "general public ignorance" and so even if treatment for some things is unnecessary, it is essential to show that control of all disposable effluent is in the hands of a responsible station engineer.

This policy is to be applied to all outgoings from the station including the ordinary domestic sewage. Bearing this in mind we can examine the various methods of disposal that are available and listed above.

Decay Considered

Natural decay occurs in the case of expended and fractured fuel elements left in the cooling ponds. Certain other items could also be allowed to decay to reasonable limits, providing the contamination was short lived.

This facility is also used when holding tanks are constructed, although the decay period may only be hours rather than days. However,



Longitudinal section through the effluent treatment plant. On the top floor are shown the scrubber tank and sump, cation exchange units for the pond water treatment circuit, and the acid tanks. On the floor below there are a row of ceramic cloth filters while at the bottom are holding tanks for active and potentially active effluents and the ebb tanks

for the bulk of the liquid effluents from Berkeley holding for decay as a treatment is not practical due to the quantities involved.

Disposal involving dilution and dispersion would be ideal for use at Berkeley mainly because of the large quantities of dilution water available.

The cooling water system for the main condensers, will circulate and dispose at the rate of 1,000 cu.ft/sec during power load conditions.

Radioactive effluents could be disposed of through the outfall to this system. During low tidal conditions, because the outfall is not flooded total dilution available would be due to the cooling water circuit only. On ebb tide conditions the dilution afforded by the river flow could also be added.

Although this method may have suited the need of the station, there were still the " public ignorance " and unknown factors to contend with.

The Chosen Method

Disposal of radioactive water by burial is tedious and expensive and though some items will be dealt with at Berkeley by this means, most of them will be disposed of by the methods that come under the heading of concentration and storage. Sources of potentially active effluents and their routings are as follows:—

From reactor direct to potentially active drain, some via the basement sumps; from change room, via a sample system and thence direct to soil drain with means of directing where necessary to potentially active drain; from cooling pond wash-down, via a sample and sentence sump, to either soil or potential active drain; and from all sub-change rooms direct to potentially active where it enters the treatment plant proper.

Sources of active effluents are:— reactor discharge sump; close cycle coffin wash; and decontamination bay.

Potentially active effluents pass into the treatment plant through an oil trap barrier and into the holding tanks. These are twin 3,000 gal hopper bottom concrete tanks with no-float control and stirrers.

Ceramic Cloth Filters

Here the effluents are sampled and " sentenced " to either the soil drain or treatment. Treatment continues through sand pressure filters and then, if necessary, through ceramic cloth filters which can be backwashed on to collecting filters. Effluent then enters the ebb tide tanks. These are governed by no-float controls and the final effluent is pumped out during ebb flow into the valve chamber on the cooling water outfall. Before it is passed into the outfall, the effluent is monitored for radioactivity as a safety precaution.

Coarse particles are filtered out prior to this treatment and there is provision for introducing a filter aid into the line. Mechanical filtration on all the effluent is aimed at 5 micron size.

The filter " crud " is backwashed into backwash collection tanks. These tanks are equipped with de-watering arms and the settled sludge is drawn off and again de-watered probably by sludge presses and " canned " for disposal.

The same routine is followed with active effluents but on a separate treatment stream. Backwashing of the sand filters is done by wash water from a tank using raw town water, back to the backwash collection tanks.

Canning Allowed For

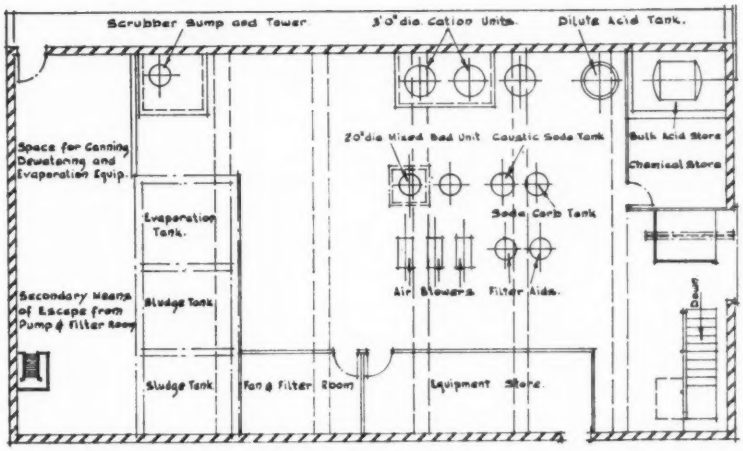
Provision is to be allowed for the installation of evaporating tanks with canning facilities, if this method of treatment and water reduction is found necessary. Space is also allowed for the later addition of expendable (non-regenerable) ion-exchange columns, which can be either on site or disposed to one of the AEA establishments.

The treatment plant can cope with 6,000 gal/day from each system, passing into an 18,000 gal ebb flow tank. Pump units with standbys are rated 1,000 gal/hr and each filter unit also takes this flow rate. The ebb flow pumps are rated at 6,000 gal/hr each.

Pipes and fittings used in the treatment plant are made of resin rubber or polythene. Tanks are lined with latex cement or some other similar substance. Filter cloths are of PVC or nylon mesh.

The pond water treatment circuit is a closed cycle system through a traditional water treatment process—filter, cation exchange; mixed bed column—with the " polished " liquid going back to the cooling pond. The " bleed " rate is about 1,000 gal/hr.

The columns are regenerated on site by the use of acid and caustic regenerants, the regenerant liquors being taken into a neutralizing tank, fitted with stirrers and dosing equipment. Cooling pond drainage for cleaning up the pond proper is pumped out into the sludge tanks and treated here as already described. The neutralized liquor and the backwash sludge tanks are linked with the de-watering and canning processes, of course.



Plan of the top floor of the treatment plant showing position of the cation exchange in units, acid and caustic soda tanks, sludge tanks and various stores. The evaporation tanks and space for canning equipment are provided in case water reduction is used as an additional treatment process

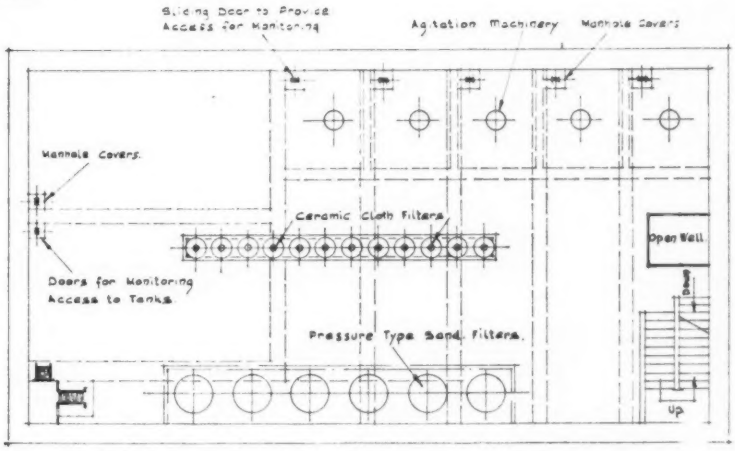
The solid active disposal plant and chute silo are designed to accommodate 20 years bunkering of waste including filter packs, sludge canned units. Each five year unit will be sealed.

Disposal to the solids unit is effected through a sealed valve muff unit in the roof and discharge is made through a special machine. Air is sucked in through the muff during discharge in order that air flow may be away from personnel and into the mortuary. The air is expelled through a breathing unit and filter.

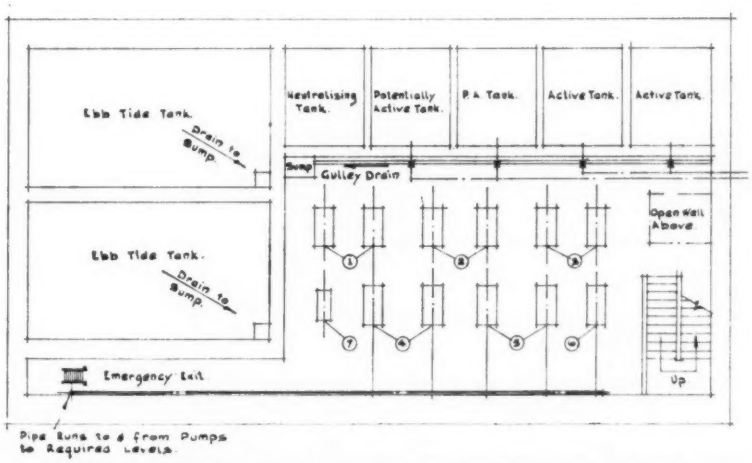
The Mortuary

The mortuary itself is 138 ft × 70 ft × 32 ft deep, mainly with walls and floor in staggered joint and waterbar construction. Generally the 4 ft 6 in. floor is of concrete construction. The earth surround affords good shielding and the roof is constructed of 6 ft thick concrete. There is no special lining provision except of a waterproof nature.

The chute silo is a specially adapted part of the mortuary to take irradiated control rods in a container and the capacity again is worked out for the estimated life of the station, i.e., 20 years. The chute silo mechanism operates similar to the muff valve above and once on the cradle inside the cradle is tipped sideways on a pivot shooting the rods into the silo.



Plan of filter floor of treatment plant showing the position of the ceramic cloth filters and pressure type sand filters. Machinery controlling the agitators in holding tanks on floor below is housed here



Holding tanks and ebb tide tanks are housed on this floor together with pumping equipment. Key to the pumps: 1, suction pumps for neutralizing evaporation tanks; 2, suction pumps for potentially active holding tanks; 3, suction pumps for active tanks; 4, suction pumps for ebb tide tanks; 5, backwash pumps; 6, wash water pump, and 7, sump pump

Shock Protection

To accommodate the shock of falling objects into the mortuary the floor requires protection and a 6 in. bed of gravel is probably as good as anything for this purpose. Alternatively old rail-lines bedded in could serve the same purpose. Tell-tale drains and detection sumps are constructed similar to that in the cooling pond.

Acknowledgements are made to the chief project engineer of the Central Electricity Generating Board, the chief engineer of AEI-John Thompson Nuclear Co., Ltd., the principal of the South East London Technical College and to the Consulting Engineers, W. S. Atkins and Partners for permission to publish this article.

IRL

Reactor for Industrial Research

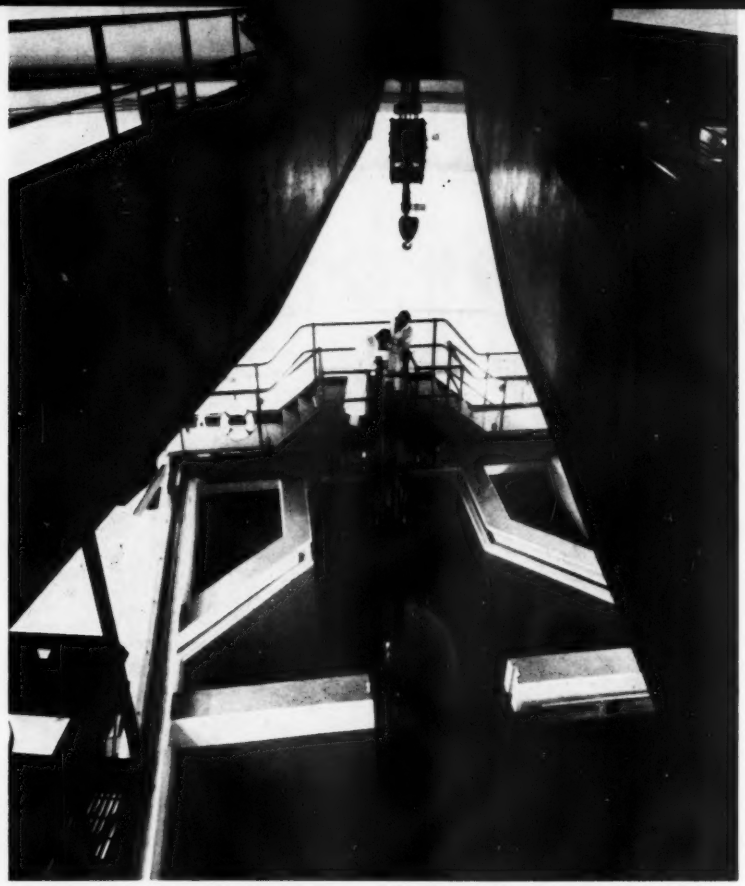
IRL are the initials of Industrial Reactor Laboratories Inc., a $4½m. nuclear research centre established by 10 non-competing industrial companies to conduct basic and applied research relating to their respective fields of interest. It is claimed to be the largest privately-owned and operated nuclear research facility for industrial research anywhere in the world. The centre is built near Plainsboro, New Jersey, about five miles from Princeton and is about midway between New York and Philadelphia.

The IRL research centre comprises five principal structures:

(1) An aluminium-sheathed concrete structure 87 ft high, housing the swimming pool type reactor.

(2) A laboratory and administration building, connected to the north side of the reactor structure. The building houses a " hot " laboratory area for handling radio-active materials; individual research laboratories for the participants; and administrative offices, health facilities, a reception area, and miscellaneous service facilities.

The 87 ft aluminium dome housing the 5 MW, IRL "swimming pool" reactor, near Plainsboro, New Jersey



Looking down into the " swimming pool " of the IRL reactor. Twenty-seven feet below the surface of the water is the reactor core. Capacity of the reactor is 5 MW

(3) An underground pump house, containing large capacity pumps to provide the circulating water system for the reactor.

(4) A service building.

(5) Cooling towers for water and air-conditioning systems.

A large, aluminium-sheathed concrete dome houses the reactor, which was designed, like the reactor itself, to provide maximum safety from radiation hazards. The 87 ft high dome is constructed of 12 in. and 8 in. concrete walls on the lower portion and 3 in. gunite on the upper portion. The outside is completely sheathed with roofing felt, fibreglass board, and a 16-gauge mill-finish aluminium skin. A slight vacuum is maintained within the dome by a special pumping system. Two air locks provide for traffic between the dome and the laboratory building—isolating the dome at all times.

Magnetite Concrete

The 5 MW swimming pool type reactor, which provides a source of neutrons, gamma rays and radio-active isotopes, uses demineralized water, as moderator, coolant, and shield for the chain reaction. The pool has walls 1½ to 10 ft thick, depending on nearness to the source of radiation. The lower 15 ft is constructed of magnetite concrete weighing 235 lb/cu.ft while the upper walls are poured with regular concrete aggregates.

The pool is serviced by a mezzanine at the 30 ft level where a control room houses the reactor's operating console. Thirty feet above the mezzanine is a 12 ton capacity circular crane spanning 64 ft. It has a 360° travel on a circular rail, and with a total weight of 54,000 lb it is one of the largest of its type in the U.S.A.

Base Ports

Experiments are carried out at the base of the reactor through ports which open into tubes extending through the water within various specified distances from the radio-active fuel source. In addition, a dry chamber equipped with a 16-ton steel and lead door also is provided. Fuel requirement of the reactor to bring it to its full operating power is about 4.5 kg of enriched uranium.

In addition to various heavily-shielded facilities for the storage

and handling of radioactive materials that have been exposed in the reactor, the "hot" laboratory accommodation includes three special cells in which experiments can be handled by "master-slave" mechanical manipulators.

Each of these cells is constructed of high-density concrete, 3 ft thick, faced with steel skins, with access through doors weighing 13 tons each. The operator manipulating materials by means of the mechanical "hands" views the operation through special lead glass radiation windows whose thickness equals that of the cell walls.

Other Facilities

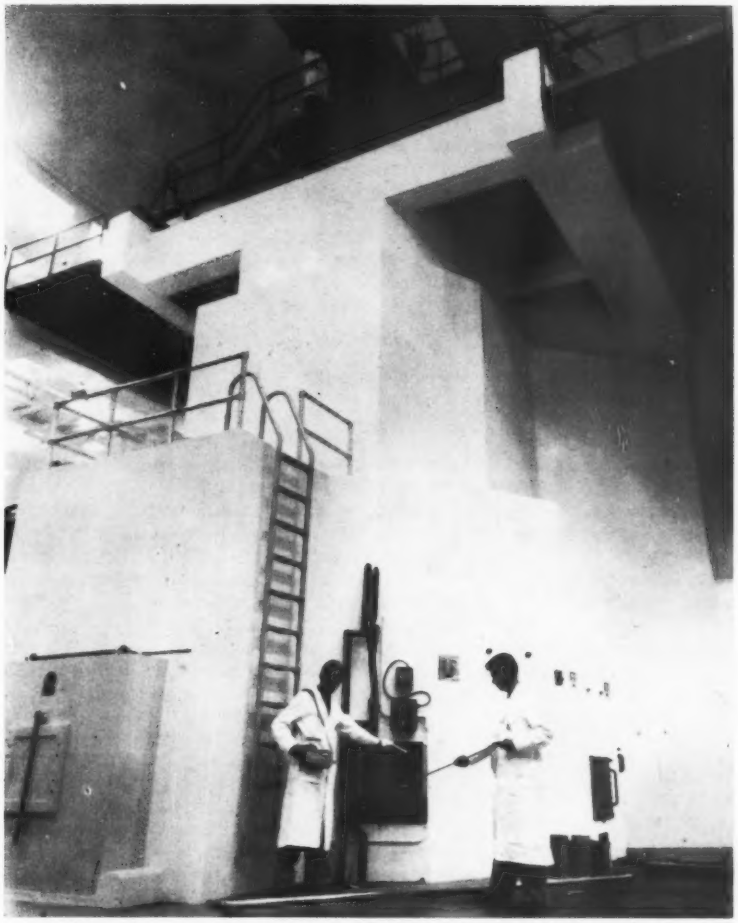
Besides an underground pump room, storage and hold-up tanks, glass-lined tanks, and contaminated storage tanks, other facilities include: a one-storey service building housing an incinerator, carpenter shop, shipping room, and primary switch-gear room; two cooling towers; and an elevated water storage tank. There are also in the main building a health physics room, waste sampling room, reception area, conference rooms, lunch room, air conditioning machinery, utilities; dark room, glass-blowing room, and maintenance shop.

The 10 participating companies are: American Machine & Foundry Co., American Tobacco Co., Atlas Powder Co., Continental Can Co., New York, Corning Glass Works, National Distillers and Chemical Corp., National Lead Co., Radio Corporation of America, Socony Mobil Oil Co., and United States Rubber Co.

Tobacco Research

In 1952, research scientists of The American Tobacco Co., along with Medical College of Virginia personnel began pioneer studies using "labelled" or radioactive tobacco. This makes it possible to trace the disposition of tobacco components during and after combustion, and to measure the effects of smoking with a precision possible in no other way. Participation in Industrial Reactor Laboratories, Inc., will enable the company to extend and enlarge this basic line of research.

Corning Glass Works will use the IRL facilities to accelerate the development of stronger, more durable glasses and ceramics for space age technology. Company scientists will employ the neutron and gamma radiation sources as a major research tool in seeking new compositions which will have exceptional strength combined with unusual resistance to corrosion and heat shock.



Base of the IRL reactor. Its walls are 3 ft thick and are constructed of magnetite concrete

The effect of nuclear radiation on glasses and ceramics will be studied in a programme to develop new materials which will withstand this radiation and will meet the requirements of products needed in the practical use of atomic energy.

Lead Co.'s Interest

Probable uses by National Lead Co., will include the study of the structure of many metals and alloys used and sold by the company, the development of new and improved shielding materials, the development of isotopes which may lead to economies from the standpoint of process and quality control and product identification, and general application of reactor radiation to promote and initiate chemical reactions to aid in the solution of the company's technical service, research and development problems.

Expanding Research

The American Machine and Foundry Co., will expand its current programmes and initiate new studies in both basic and applied nuclear science, with major emphasis on improvement of its widely varied product line and the development of totally new products.

Socony Mobil is participating in the project to obtain a readily accessible, flexible and generous source of composite beta, gamma and neutron radiation: the company's research is aimed at the improvement of petroleum refining and petroleum products, the production of new petroleum chemicals, and the use of new energy sources. With the help of the reactor Mobil expect to

be able to develop superior radiation resistant fuels, lubricating oils, waxes and greases as well as new refining and petroleum chemical processes.

Continental Can Co.'s participation in operation of the IRL research reactor is part of the company's long range programme to explore all significant aspects of new technologies in the container manufacturing industry and related operations. For a number of years the company has actively participated in research on radiation processing of foods and believes that successful development of this method might have a major impact on food processing, packaging and distribution for both military and civilian markets. The IRL reactor facilities will be useful in carrying out the company's studies in this field.

R.C.A. Success

As a specific example of its interest in nuclear phenomena as applied to electronics, Radio Corporation of America has already explored with initial success the direct conversion of atomic radiation to electrical energy through an experimental atomic battery. The facilities of Industrial Reactor Laboratories will permit further work to be carried out in this potentially important area.

Participation by the National Distillers and Chemical Corporation will enable the company to study the effects of nuclear radiations on materials of construction for nuclear reactors. National Distillers through its affiliate, Mallory Sharon Metals Corporation, holds a contract with the U.S. Atomic Energy Commission for the production of high purity zirconium, a key raw material in the production of nuclear reactor components. National's USI division produces metallic sodium and the company is currently interested in developing a variety of new chemicals and non-reactive metals which may hold promise as control, moderator and cladding materials for fuel components for the nuclear reactors of the future.

New Materials Possible

Through atomic radiation entirely new families of plastics and rubber-like materials can be produced.

Research at this nuclear reactor will assist the United States Rubber Co., to determine the feasibility of a reactor designed to produce both radiation for these processes and steam for heat and power. The company expects to produce radioactive isotopes by exposing various elements to the neutrons from the reactor. By these studies new uses for these radioactive materials may be found.

For Three Reasons

Atlas Powder Co., became one of the participants in Industrial Reactor Laboratories Inc., for three reasons. First—to acquire a valuable and unique means for basic research in the promotion of chemical reactions, chemical synthesis, modification of products and processes, and similar fields. Second—it believes that nuclear radiation will be used increasingly in chemical manufacturing processes in the years to come. Third—because one of the objectives of the company's long range research and development programme is to keep abreast of all developments that may help it provide better products for the many industries that it serves.

Theoretically worth investigating, with some possibility of commercial application, is the effect of radiation on emulsions, catalysts, and other systems. The company will also be studying various types of chemical syntheses with the hope of being able to reduce the number of steps now required to produce certain chemical end-products.

Book Reviews

Introduction to Neutron Physics, by L. F. Curtiss. Size 6 in. × 9 in. × 391 pp., 250 illustrations. Price 73s. Published by Van Nostrand Company.

This is the first work to be published on neutron physics since D. J. Hughes' excellent "Pile Neutron Research" in 1953. The present book is, I think, less useful to nuclear technologists because it pays less attention to the reactor as a source of neutrons. Instead it tends to catalogue all possible types of neutron source and neutron detector. The emphasis is not on fundamental physics, although there is a somewhat sketchy chapter on neutron-nuclear interactions, instead it is on the techniques; for instance there is a good account of the methods used in neutron diffraction experiments. I myself wonder whether "Neutron Physics" is a good subject for a book. It is not possible to dissociate fundamental neutron physics from, say, proton-physics or pion-physics. On the other hand, the problems of neutron interactions in a reactor are extremely specialized, and should form part of a textbook on reactor physics. I am afraid the present book tends to compromise, and in this way may fail to satisfy either the pure physicist or the reactor technologist. Of course, this is not to deny that there is a lot of useful information presented in the book.

H. W. B. Skinner, FRS.
Liverpool University

British Instruments — Directory and Buyers' Guide. Size 11 in. × 8½ in. × 615 pp. Price £2 2s. Published annually by United Science Press Ltd., in association with the Scientific Instrument Manufacturer's Association.

A completely new publication, this combines in one volume information previously available in "British Scientific Instruments," published by SIMA, and "The Instrument Directory and Buyers' Guide," published by United Trade Press Ltd., both of which have now been discontinued. Principal features of the new publication are a classified list of scientific and industrial instruments and components giving the names of the manufacturers of equipment under such classification, an alphabetical list of the manufacturers and their overseas agents and a 300 page section which gives details of the products of over 150 manufacturers. A foreign glossary section in French, German and Spanish will enable speakers of these languages to use these parts of the directory without undue difficulty. Other sections include details of the various British associations and organizations concerned with instrumentation and control, a list of firms specializing in the installation of control equipment and a guide to trade names. There is also a list of British Standards Institution specifications relating to instruments. Sir David Eccles, President of the Board of Trade, has written a foreword to the first issue of this highly useful and informative publication.

Literature Received

THE applications and advantages of organic moderated reactors as a power source are dealt with in a booklet recently published by Atomics International, a Division of North American Aviation, Inc. This type of reactor uses a hydrocarbon liquid, such as terphenyl, for both coolant and moderator, thus permitting the reactor to operate at low pressures while producing steam at pressures and temperatures compatible with efficient plant performance. Efficiency, reliability and safety of this reactor type have been extensively tested in the full-scale OMRE project at Idaho Falls which has been in operation since 1957. Called "The Organic Reactor Nuclear Power Plant," the AI book, with the help of very readable text and colourful diagrams, describes the design, construction, operation and economics of the reactor. Other sections cover operational staff requirements, installation programmes and other work of Atomics International.

Effect of Irradiation on Fuel Materials*

by J. H. Kittel and S. H. Paine

Argonne National Laboratory, Lemont, Illinois

ONE of the most difficult technical problems which must be solved in order to obtain economic nuclear power is the development of fuel materials which can sustain fission of a large fraction of the total atoms in the fuel without serious damage to its desirable engineering properties. In particular, dimensional stability of fuel elements must be maintained during extended reactor exposure, or such items as heat transfer, cladding integrity, and even criticality may be adversely affected.

Research at Argonne National Laboratory on satisfactory solid fuel materials for power reactors has included extensive irradiation investigations of fuel based on metals and on ceramics. Emphasis in these investigations has been placed on obtaining information needed for development of fuel elements for civilian power reactors. Therefore, many of the more promising fuel materials have been irradiated to relatively high burnups at elevated temperatures, as would be necessary for low fuel costs.

An additional consideration has been that in the case of thermal reactor fuels, attention has been mainly confined to unalloyed uranium and to uranium with only small alloying additions, so that little or no enrichment would be required. Most of the irradiations have been made on cylindrical specimens, 1.00 in. long and with diameters ranging from 0.125 to 0.250 in. Unless otherwise noted, the specimens were irradiated in NaK capsules under conditions where the specimens were not physically restrained.

The dimensional stability of the specimens has been of primary interest. If the rate at which a fuel specimen changes in length when irradiated is constant, the rate may be expressed as a growth coefficient, G_l,[1] which is obtained from the relation:

$$G^1 = \frac{1}{L}\frac{dL}{dN} = \frac{\text{In } L/L}{\text{fraction of total atoms fissioned}} \quad (1)$$

Where length changes are small, the following approximation may be used:

$$G_l = \frac{\%\text{ length change}}{\text{at. }\%\text{ burnup}} \quad (2)$$

Experiments in which fuel specimens have been taken to high burnups have shown that in some cases G_l may vary with burnup. In these cases, equation (2) has been used. Comparisons of the value of G_l for various materials, as is done in this article, furnishes a convenient means of determining relative dimensional stabilities.

A previous paper[1] has described changes which are observed in rolled uranium irradiated to moderate burnups. More recently, an investigation has been made to determine the effects of relatively high burnup on natural unalloyed uranium. In this study, almost 2 at. % burnup was achieved in some specimens because of conversion of appreciable amounts of U-238 into Pu-239, which contributed fissions in addition to those from U-235. Irradiation specimens were prepared with the following metallurgical histories.

1. Rolled at 300°C.
2. Rolled at 300°C., heated to 735°C. for 30 min, and water quenched.
3. Rolled at 300°C., heated to 735°C. for 30 min, water quenched, and held at 575°C. for 2hr.
4. Rolled at 600°C.

Uranium rolled at 300°C. (history 1) contains a large component of (010) poles parallel to the rolling direction, whereas uranium rolled at 600°C. (history 4) contains much less of the (010) component[2]. Uranium quenched from the beta phase (histories 2 and 3) retains relatively little of the preferred orientation resulting from prior rolling. The anneal at 575°C. (history 3) was used to permit the alpha phase

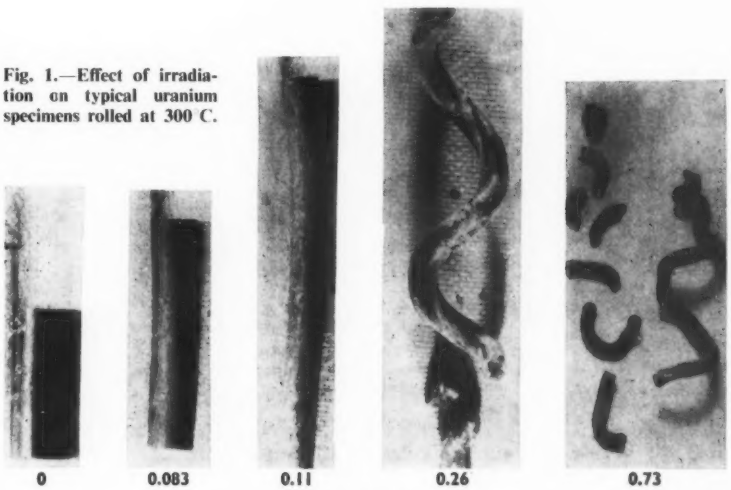


Fig. 1.—Effect of irradiation on typical uranium specimens rolled at 300°C.

**Paper presented at the 2nd International conference on the Peaceful Uses of Atomic Energy, Geneva, 1958*

to recrystallize into an equiaxed structure.

Fig. 1 shows typical 300°C.-rolled specimens after burnups ranging up to 0.73 at. %. The two specimens with the higher burnups were found to have coiled about in their irradiation capsules because sufficient space was not available to accommodate the amounts of elongation which they developed. Growth of unrestrained specimens is shown in Fig. 2. Quenching the 300°C.-rolled material from the beta phase effected marked changes in its behaviour under irradiation, as shown in Fig. 3. The lengthwise growth rate of the uranium was decreased considerably, but, as the photographs illustrate, considerable surface roughening developed under irradiation. The increased

Fig. 2.—Length changes in irradiated uranium specimens rolled at 300°C.

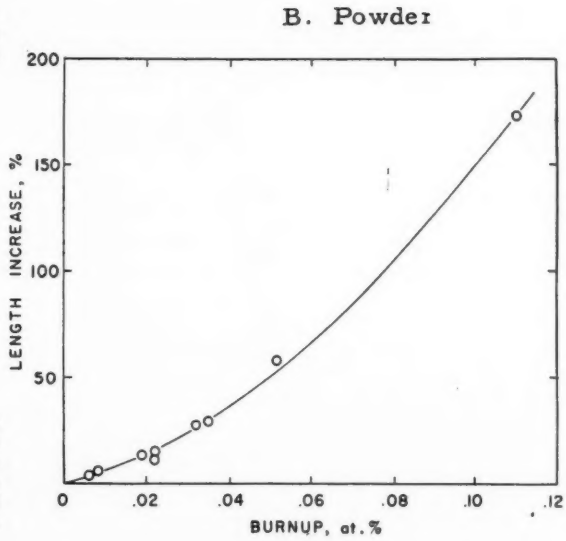
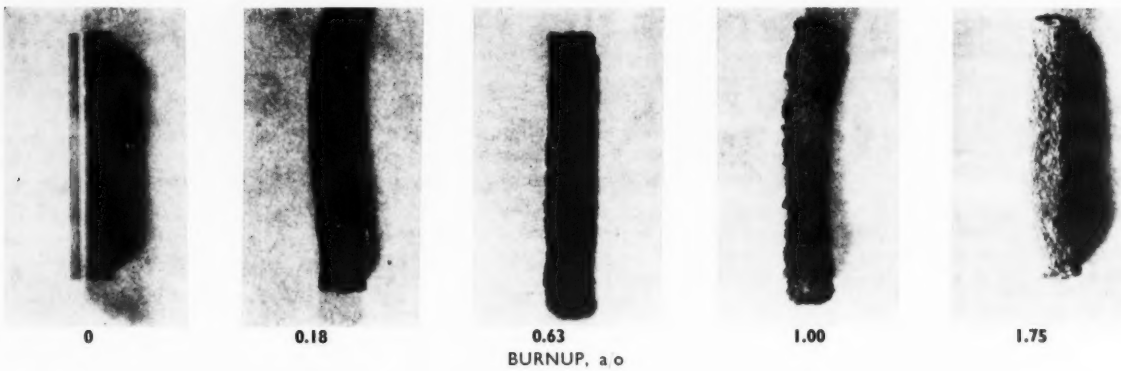


Fig. 3.—(*Below*) Effect of irradiation on typical uranium specimens rolled at 300°C. and quenched from the beta phase



surface roughening is presumably due to grain growth which resulted from the beta heat treatment.

Recrystallized specimens, shown in Fig. 4, displayed essentially the same behaviour as unrecrystallized material. The length changes in both types of material are shown in Fig. 5 as a function of the total burnup which they received. It may be noted that the growth rates diminished at higher burnups. The appearance of typical 600°C.-rolled specimens after irradiation is shown in Fig. 6, and their length changes with increasing burnup are shown in Fig. 7. The irradiation changes in this material, as might be expected, were intermediate between those shown by the 300°C.-rolled specimens and those which were quenched from the beta phase.

Fig. 8 shows a comparison of irradiation growth of the specimens, and illustrates the improvement in dimensional stability which results when uranium with the unfavourable (010) texture is quenched from the beta phase. The better stability of the 600°C.-rolled material compared to the 300°C.-rolled specimens indicates that the marked dependence of irradiation growth rate on rolling temperature, shown previously for low burnups,[1] persists to more extended exposures.

The relative dimensional stabilities of the uranium specimens may be evaluated more quantitatively by

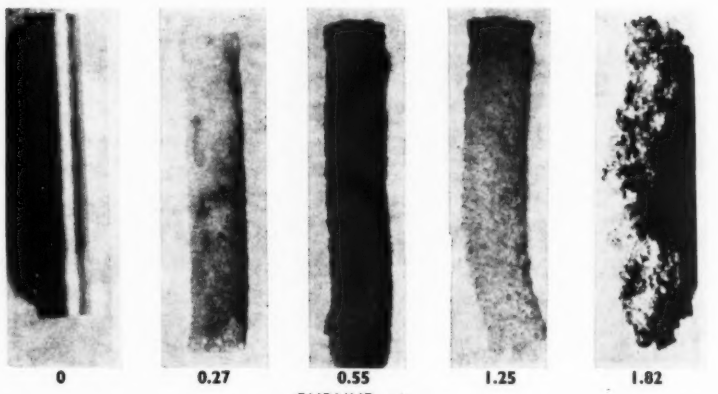


Fig. 4.—Effect of irradiation on typical uranium specimens rolled at 300°C., quenched from the beta phase and recrystallized at 575°C.

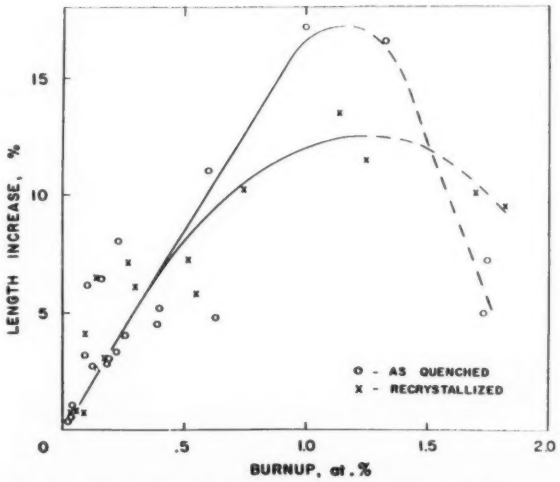


Fig. 5.—Length changes in irradiated uranium specimens rolled at 300°C., quenched from the beta phase, unrecrystallized and recrystallized

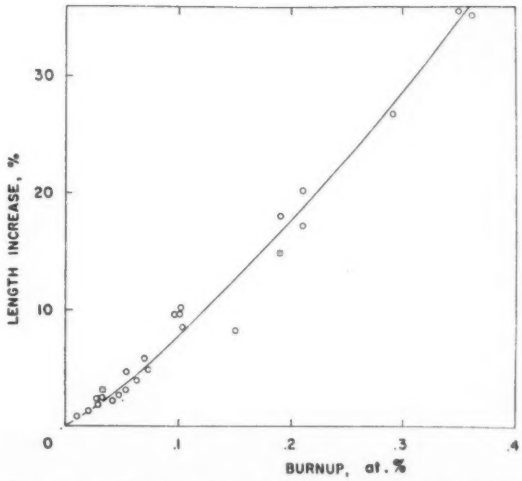


Fig. 7.—Length changes in irradiated uranium specimens rolled at 600°C.

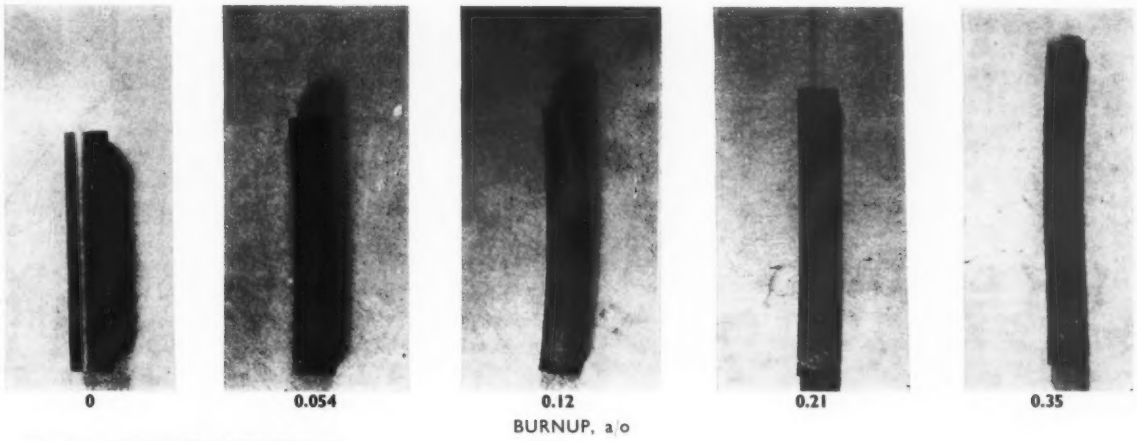
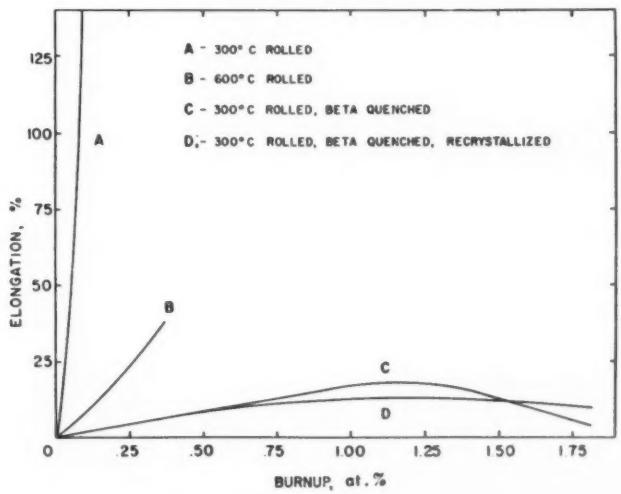


Fig. 6.—(*Above*) Effect of irradiation on typical specimens of uranium rolled at 600°C.

Fig. 8.—(*Below*) Effect of different fabrication histories on the lengthwise growth of uranium under irradiation


A - 300° C ROLLED
B - 600° C ROLLED
C - 300° C ROLLED, BETA QUENCHED
D - 300° C ROLLED, BETA QUENCHED, RECRYSTALLIZED
ELONGATION, %
BURNUP, at.%

comparing their average growth coefficients. Considering material irradiated up to about 0.5 at.%, for the 300°C.-rolled material, $G_1 = 690$, for the 300°C.-rolled and beta-quenched material, $G_1 = 25$, and for the 600°C.-rolled material, $G_1 = 77$.

Observed density decreases in the irradiated specimens are shown in Fig. 9. It is evident that the density changes were essentially independent of prior fabrication history. Initially, the densities of the specimens decreased at a rate of about 4.8% per at. % burnup. After about 0.5 at. % burnup the rate of density decrease began to diminish, so that specimens irradiated to about 1.8 at. % burnup had decreased in density only about 3.9%.

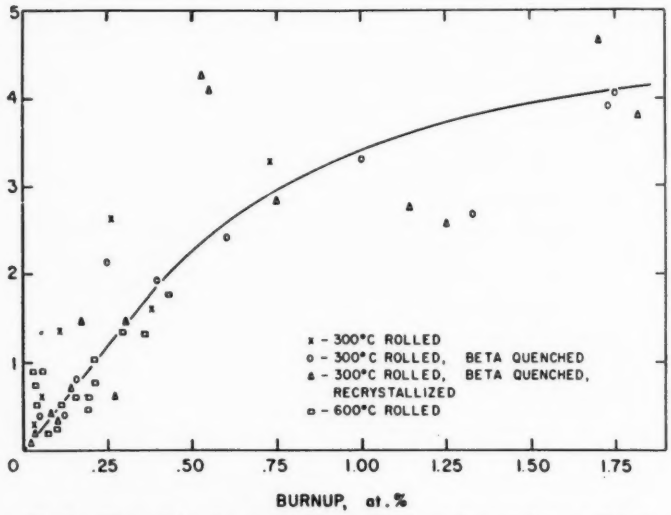


Fig. 9.—Observed density increases in irradiated uranium specimens rolled at 300°C. and 600°C.

The difficulty of obtaining a simultaneous condition of random orientation and small grain size in uranium by conventional metallurgical techniques led to an investigation of material fabricated by powder metallurgy. Experimental irradiations were made on compacts prepared by hot-pressing uranium powder to both full and less than full density, and by hot-pressing uranium hydride powder to full density. During hot-pressing, the uranium hydride decomposed into uranium and hydrogen, so that the specimens were converted into pure uranium during fabrication.

The full density specimens prepared from uranium powder were found to shorten under irradiation in the pressing direction and to develop a corresponding elongation perpendicular to the pressing direction. End-pressed specimens shortened in length and increased in diameter, whereas side-pressed compacts increased in length and their originally circular cross sections became elliptical. The shortening of end-pressed specimens, both solid and cored, is shown as a function of burnup in Fig. 10. The shortening of the end-pressed compacts was at an average rate of $G_1 = -23$. The specimens prepared by hot-pressing to less than full density contained up to 13% porosity. Under irradiation, they deformed in the same manner as the full density compacts. The amount of porosity in the specimens before irradiation did not appear to affect the rate of dimensional change.

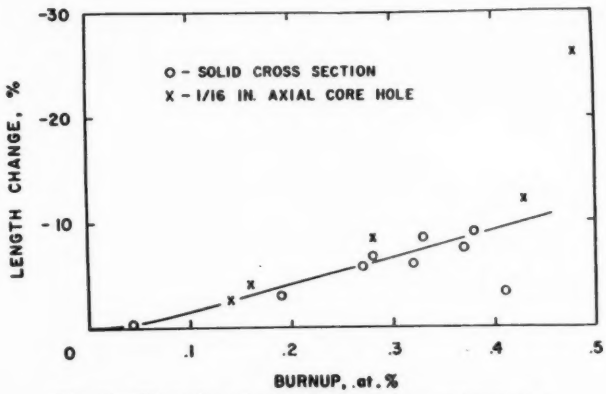


Fig. 10.—Shortening of end-pressed uranium specimens as a function of burnup. Results with both solid and cored specimens are shown

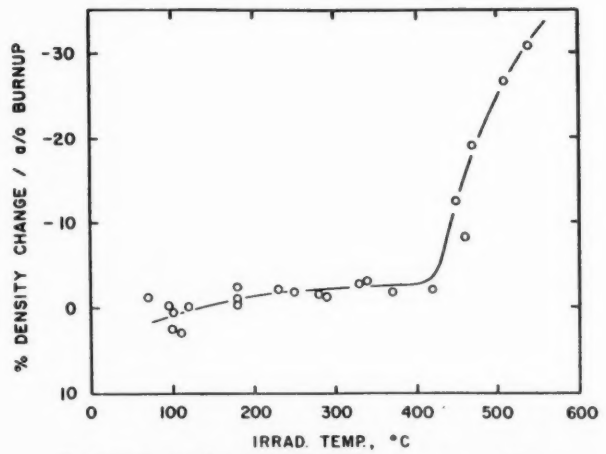


Fig. 11.—Density changes in irradiated specimens prepared from uranium hydride powder. As can be seen changes were dependent upon irradiation temperature and above about 430°C. a high rate of volume increase or swelling was observed

The uranium specimens prepared by decomposing uranium hydride powder all elongated under irradiation in the pressing direction at an average rate of $G_1 = 19$, in contrast to the specimens prepared directly from uranium powder. As shown in Fig. 11, volume changes in the compacts prepared from uranium hydride powder were dependent upon irradiation temperature. Above about 430°C., a high rate of volume increase, or swelling, was observed. Metallographic examination of some of the swelled specimens disclosed that the volume increases were the result of formation of a large central void and a surrounding zone of porosity, as shown in Fig. 12. Similar porosity in uranium irradiated at elevated temperatures has been reported by Pugh[3]. It is believed that the pores were formed

as a result of nucleation and growth of bubbles of volatile fission products, and that the large central void may have resulted from an effective inward movement and coalescence of bubbles. Because of the high radial temperature gradient in the specimens (on the order of 1,000°C./in.) it would appear likely that an expanding gas bubble would preferentially strain the matrix metal on the inward side of the bubble, since this metal is at the highest temperature and would therefore have the lowest creep strength.

As has been shown in preceding sections, it is difficult to obtain small randomly oriented grains in unalloyed uranium by varying fabrication procedures or heat treatment. However, certain alloying elements have been found to be highly effective when added to uranium in enabling fine-grained randomly oriented material to be obtained by fabrication techniques or heat treatment.

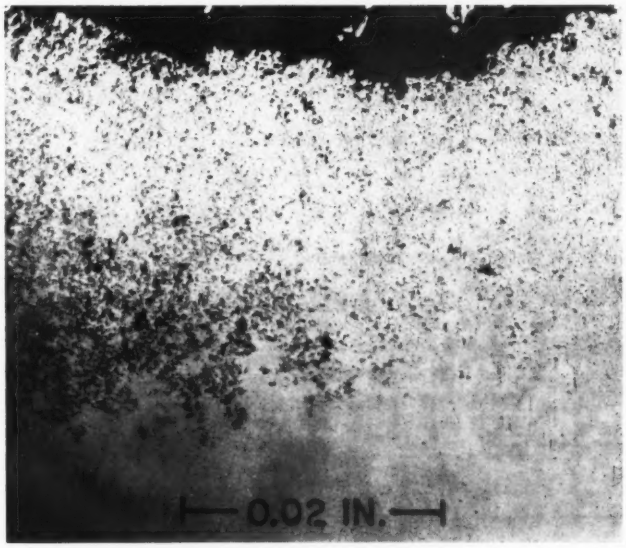


Fig. 12.—Metallographic examination of irradiated specimen prepared from uranium hydride powder subjected to a temperature of over 430°C. The large central void and surrounding zone of porosity seen in this plate are the cause of the swelling that takes place in specimens subjected to high temperatures

(To be continued)

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[1]PAINE, S. H. and KITTEL, J. H., "Irradiation Effects in Uranium and Its Alloys." Proceedings, International Conference on the Peaceful Uses of Atomic Energy, 7:445-454 (1955).

[2]FOOTE, F. G., "Physical Metallurgy of Uranium and Its Alloys." Proceedings, International Conference on the Peaceful Uses of Atomic Energy, 9:33-68 (1955).

[3]PUGH, S. F., "Radiation Damage in Fissile Materials." *Progress in Nuclear Energy*, 1, Series V, 652-671, Pergamon Press, London (1956).

Acknowledgement is made by the Editor to Argonne National Laboratory for supplying photographs used in this article.

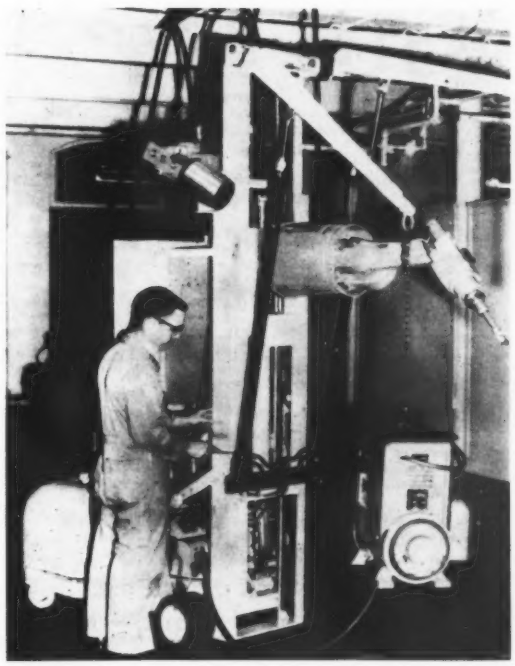
B & W Robots Team

THE Atomic Energy division of the Babcock & Wilcox Co., U.S.A., jointly with the Research and Development Centre of the same company, have recently developed a new type of highly specialized mechanical robots "team" designed to perform nuclear reactor maintenance and repair functions in the radiation fields too "hot" for humans to touch. The new atomic "automatons" are operating at the Lynchburg, Virginia, plant of the company, responding to sound and performing a great number of human functions.

The robots are one phase of a facility established by the company to develop prototypes of equipment required to maintain advanced types of nuclear reactors that will use circulating liquid metal as the fuel. Known as the "Engineering Prototype Development Facility," the unit, located in the Bates Building at Lynchburg, is part of a contract Babcock & Wilcox hold from the U.S. Atomic Energy Commission to study, develop and build a circulating-fuel reactor experiment.

Consisting of six units, the robot fleet will be independently and remotely controlled by radio signals from a "master brain" control console. A closed-circuit television system, built by Diamond Power Specialty Corporation, will make the radioactive work area easily visible in the control room of the reactor.

Largest and most complex of the robots is a three-ton, 8 ft high fork-lift truck with three arms especially adapted to the atomic functions they will perform. The most versatile of the three arms is a mobile manipulator capable of duplicating many human wrist and arm functions. The two auxiliary arms can easily lift a small wrench or a 1,000 lb object 15 ft in the air.



Training Nuclear Engineers

at SOUTHAMPTON UNIVERSITY

A huge building programme is under way at Southampton, with Basil Spence and Partners as the architects. When completed there will be a vivid contrast between the old (*left:* the main building) and the new (*above:* engineering block)

ALTHOUGH Southampton University is only seven years old, it has foundations as a University College for 50 years and as the Hartley Technical Institute for 40 years before that. As with most universities these days, the demand for places considerably exceeds the accommodation available. The expansion in student numbers has been rapid—900 in 1952 to about 1,500 this year—and is expected to reach 2,000 in the early 1960's. To meet this demand a large building programme, mainly for engineering and science is in progress with Basil Spence as the architect.

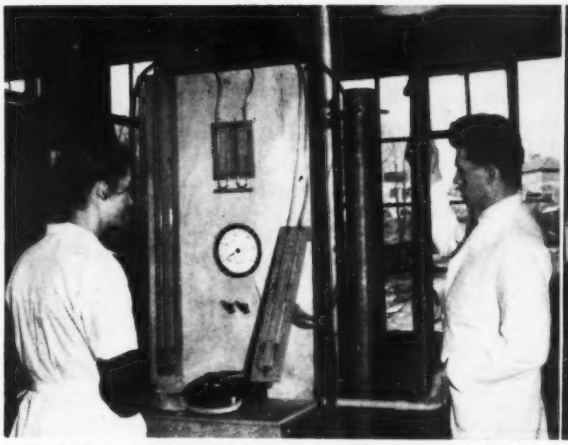
Dr. N. S. Grassam, PhD, BSc(Eng), AMICE, AMIMechE, who is in charge of the nuclear engineering programme at the Southampton University. Before going to Southampton in 1951 he was a senior lecturer at the Royal Naval College, Greenwich, and before that at the Admiralty Gunnery Establishment, Teddington. By training, Dr. Grassam is a structural engineer and early in his career carried out research into stresses in concrete

Interest in nuclear matters in this university has developed in the mechanical engineering department, and in the three years in which courses have been arranged it has shown a steady progress. Responsible for this development is Dr. N. S. Grassam, who received his nuclear training at the Harwell Reactor School. He takes the view that, although it was necessary to concentrate on training qualified engineers and physicists in nuclear science when the nuclear industry was starting, now that this immediate need is satisfied, fundamental training in nuclear power should form a part of undergraduate courses. Industry, he says, can ill afford to release its experienced engineers for long periods of training.

The engineering students at Southampton take a course spread over three years. Students selected for an Honours degree take two years over a general course, and in their third year make specialized studies and undertake a research or development project. Other students take three years over the general course and are awarded an Ordinary BSc(Eng) degree. The subject called Nuclear Power is offered to mechanical and electrical engineering students and is available at Ordinary and at Honours level.

It is considered that the main difficulty for engineering students is a lack of knowledge of nuclear physics. The ordinary course in nuclear power seeks to remedy this by giving the fundamentals of nuclear physics together with general information about reactors, nuclear metallurgy and the like, to indicate the scope of the new technology. The detailed extensions of the conventional branches of engineering to cover special nuclear technologies can be learned on the job and by part-time study after the graduate reaches industry.

Dr. Grassam was able to get over the difficulty of having no facilities for nuclear experiments in the university by going to Harwell, where with the co-operation of the principal of the reactor school, he obtained first class experimental training for his students. Each student visits



The heat transfer built by students to study the properties and performances of fuel cans

Experiment for investigating heat resistance and radiation properties of high density concrete

Harwell once in each term for a whole day to undertake experiments involving the measurement of radiation. The students have the unique opportunity of carrying out a full scale shielding experiment on the BEPO reactor, and use a sub-critical uranium-graphite assembly for an exponential experiment. Visits are also made to study some of the research reactors and other facilities in the establishment. Southampton University was the first to make such an arrangement with the reactor school. Visits to the Berkeley nuclear power station site and to the AERE, Winfrith Heath are also made.

Tank for studying flow patterns of coolants round fuel elements. Models representing a finned element can are submerged in water (*above*) and the course taken by the water traced by means of a suspension. Photographic records of the tracings are kept (*right*)

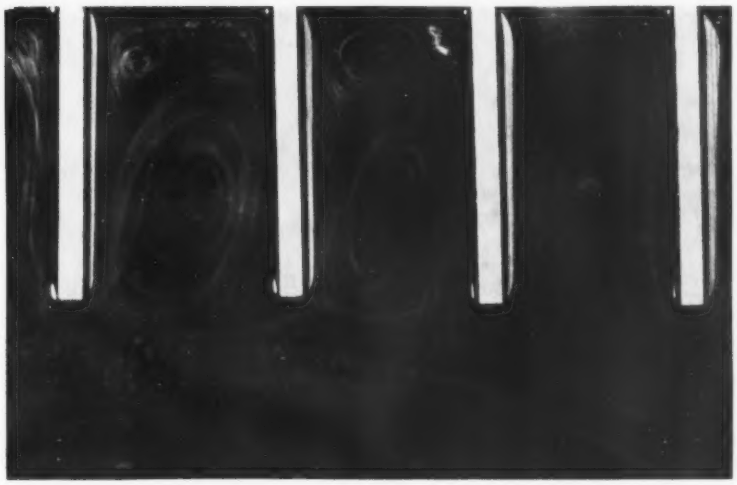
Students who elect to specialize in nuclear power in their honours year have an extensive course of lectures on reactor heat transfer, on reactor control and on shielding. These men are potential research workers for industry and the UKAEA. They may also undertake a project related to a nuclear engineering problem. For instance, over the past three years students have gradually developed and constructed a heat transfer test rig which simulates a channel in the core of a graphite-moderated, gas-cooled reactor. Within the channel various finned cans with a heating element inside—representing the canned uranium fuel element—can be placed. Air is blown over the finned cans and temperature and pressure distributions can be measured.

Another student is engaged in investigations of the properties of high density concrete as is used in reactor shields. From this work it can be seen that, although no facilities are available in the university for nuclear radiation experiments, nuclear engineering research is arising from these beginnings.

The number of students taking Nuclear Power has increased each year. For example it was four in 1956/57, 11 in 1957/58, 19 this year and even more are expected next session. This year the first woman engineering student to take Nuclear Power is expected to graduate.

With the completion of new buildings, space will become available to provide a nuclear radiation laboratory for some of the more elementary training experiments and for research.

Southampton University, almost equidistant from Harwell, Aldermaston, and Winfrith, and with close associations with these establishments, has great ambitions to carry out valuable research in this field; it is already making its mark as a nuclear training centre.



DOUNREAY FAST REACTOR

ELECTRICITY SUPPLY

The electricity supply and wiring arrangements in a nuclear reactor require special treatment. This extract from a paper recently presented to the Institution of Electrical Engineers by J. W. Binns and W. J. Outram describes the electrical requirements of the Dounreay fast reactor

THE main requirement for any reactor is that its coolant supply and safety system instrumentation are available at all times: this means that there is a definite need for a maintained electrical supply to meet this purpose either in full or in part. Duplicate supplies are therefore provided wherever practical, these in turn being backed up by special standby arrangements for essential plant items. Usually such standby is provided initially from a battery installation either via floating motor alternator sets for a.c. loads or direct from the battery for d.c. loads, the final standby coverage being supplied by diesel generators, either a.c. or d.c., and preferably starting-up automatically.

Simplicity Keynote

In order to ensure reliable operation of these supplies it is important that the most straightforward and simple approach should be made, in spite of the fact that this does not always prove to be the most economic arrangement, particularly in relation to running costs. The biggest economies are made by careful scrutiny of the necessity for the various items of equipment to be connected up to the essential supplies.

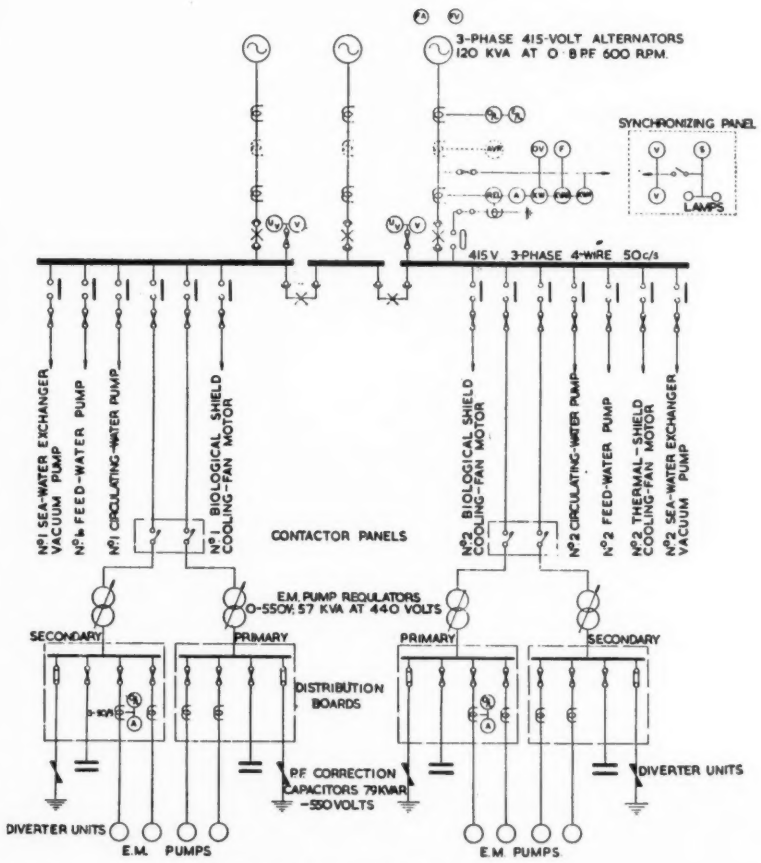
The Dounreay fast reactor is designed to develop some 60 MW of heat, and its core—which is composed of enriched U-235 fuel elements with a breeding blanket of U-238—is housed in a stainless-steel pot. To prevent radiation hazard inside the sphere the reactor is contained in a concrete biological shield having walls 5 ft thick.

The reactor outer sphere, which is 135 ft in diameter, is of mild-steel plate 1–1$\frac{7}{8}$ in. thick; this contains the reactor and its coolant equipment, etc., and is capable of withstanding any pressure variations which might occur as the result of a liquid-metal fire. The heat will be removed by a liquid-sodium cooling system, and a series of 12 heat-exchanger circuits comprising 24 primary and 12 secondary heat-exchangers are being provided.

The 12 heat-exchanger circuits each have four electromagnetic pumps for handling the liquid sodium, two in the primary circuit and two in the secondary. This provides 48 electromagnetic pumps, 24 in the primary circuits, which are located within the shield and containment sphere, and 24 in the heat-exchanger house external to the sphere. All the electromagnetic pumps are in special containers to facilitate removal, and all work in a nitrogen atmosphere.

Insulation Problem

The primary electromagnetic pumps operate in an ambient temperature of approximately 200°C., so that special consideration had to be given to the insulation of the windings. Two alternatives were suggested, namely silicone-impregnated



Wiring of electricity supply to electromagnetic pumps

glass and asbestos bound with heat-resisting cement. Tests carried out on special rigs showed that we might expect a life exceeding five years at the stated temperature with the silicone-glass insulation. The asbestos insulation, being hygroscopic, was discarded in favour of silicone glass, on the grounds that the latter was likely to be more reliable on an experimental installation.

The high rate of heat extraction necessitates a very high degree of reliability in the cooling system, which, after calculation, fixed a maximum limit of permissible loss to one-sixth of the total circulation. This governed the design of the electrical supply system to the electromagnetic pumps.

Heating Considered

Provision had to be made for the possible outage of the sodium pipe circuits, which at these times must be maintained at 150°C.; the form of heating supplied, however, must be capable of withstanding the possible temperature of 300°C. which the pipes might assume, owing to the reactor heat, while in service.

Various forms of heating were considered, e.g., heating tapes and Inconal sheathed elements. The final decision to use the latter was taken because of the high temperature and the need for good mechanical protection of the elements. The problems involved in designing this heating were complicated by their relative inflexibility, and consequently these were largely " tailor made " to suit the various pipe sections. For reliability, duplicate systems of elements have been provided on all circuits, and half-heat conditions may consequently be provided as necessary.

The main problem in this isolated part of Caithness was reliability of power supply, and although the Dounreay factory is supplied at 33 kV stepping down to 11 kV from the North of Scotland Hydro-Electric Board's overhead-line system, it was felt that, owing to the terrain, the severe winter weather and the long distance to be traversed, complete failures could not be avoided, even with the expenditure of a considerable sum on 132 kW transmission.

It was finally decided to provide diesel alternator sets to cover the load, each electrical circuit covering the requirements of one of the 12 heat-exchanger circuits with its own 120 kW diesel alternator. The alternator sets are arranged in banks of three, with one spare set in each bank, making a total of 18 for the main cooling-circuit load. In addition to the above, six 220 kW diesel alternator sets have also been provided to cover the auxiliary essential load.

This arrangement allows individual diesel sets to be shut down for maintenance without interfering with the operation of the load. The sets are of compact construction and can be readily removed for major maintenance and replaced by spare units, two of which are held ready at all times for emergency use. The engines are 600 rev/min, two-cycle units, and since they have a minimum of moving parts, i.e., no valves, rockers, etc., and because their speed is reasonably low, it is expected we shall achieve long periods of operation without serious maintenance outage; figures of 1,000 hours or more are in mind.

Voltage Changes Flow

The electromagnetic pump circuits are supplied from the 415v, three-phase busbars via induction regulators. The flow of coolant can be varied by variation of the pump voltage; suitable interlocks are provided to avoid hydraulic shock, while

(*Continued on page 317*)

DIVERSE READERSHIP

NUCLEAR ENERGY ENGINEER **is read throughout the world and by an amazing variety of people as is shown by these two enquiry cards**

Designed for different purposes, the swimming pool reactors, MELUSINE and TRITON constructed for the French Atomic Energy Commission by Societe Indatom, have certain constructional and operational differences. These are described in this article.

TWO FRENCH POOL REACTORS

MELUSINE and TRITON

THE two reactors MELUSINE and TRITON have many points in common; their tanks, or, rather, swimming pools, are not underground—or hardly so; their power is 1,000 kW and their nominal flux 10^{13} n/cm^2.

Their fuel elements, which are of the conventional type, are made of uranium enriched to 20 per cent.; they have been made by the Babcock & Wilcox Co., which produces them as plates connected by pins.

MELUSINE is a part of the Centre d'Etudes Nucléaires of Grenoble, situated near that industrial and university town. The great diversity of the work required by the university, by the industrialists and the radio-element department, in addition to that from physicians, chemists and metallurgists of the Centre itself, oriented the conception of this reactor toward the maximum elasticity.

At Fontenay-aux-Roses, on the contrary, TRITON and another smaller reactor are housed in one of four buildings of an important group located close to the first French reactor: ZOE or EL 1. It has thus been possible to give TRITON a more specific function that MELUSINE: it has been designed more particularly for shielding and protection studies.

Out and In

The difference in the objective accounts for some differences in design: the radial channels in TRITON only allow bundles of neutrons to go out, whereas those of MELUSINE permit the insertion of objects to be irradiated, and their deposit, in a dry state, against the core.

Similarly, the small rear surface of the large compartment of TRITON is provided with a window obturated by plates made of a light alloy behind which it is proposed to set up graphite assemblies or carry out dry, shielding experiments. In the case of MELUSINE, however, these experiments, which will be less frequent, will be carried out through the aluminium containing vessel.

As regards TRITON, an attempt has been made to profit from the activation of water as it goes through the core: when the latter is in the channel compartment, water, taken from under it by special channels, goes through a plexiglass coil used as an experimental source and is then returned by a pump to the deactivation cavity. This device is so designed that the output thus diverted cannot disturb coolant circulation.

Inherent Safety

It is generally conceded that reactors of this type are very safe and that this, in part, is the reason why some already have been built or are being built in fairly large numbers. This safety is due to the very principle of the swimming pool, which makes it possible to extract thermal power at low temperature and which contains the active products which, in spite of all precautions, might accidentally be released.

However, it seemed to us that the same degree of security is not a feature of all swimming pool reactors and that we must ensure that our swimming pools neither leak through their sides nor empty if a pipe which goes through a wall is broken outside it. It was also necessary to ensure that the core temperature would not rise unduly in case of a breakdown of the feed pump, if the natural convection water current which flows through the core from bottom to top took too long to take up the functions of the current forced in the opposite direction.

The two swimming pools are made of concrete. We separated the function of biological protection from that of imperviousness. In both cases we first made the concrete tanks as tight as possible; then we installed additional thicknesses of concrete where needed, in order to make the protection complete.

We wished that the concrete be impervious of itself, the inside lining merely providing an additional degree of tightness, with the main function of avoiding water contamination due to washing out of the concrete. The tank has the shape of a parallelepipedon; the bottom and sides are 60 cm thick and have been prestressed in the two dimensions of their respective planes.

By working the concrete only in compression, prestressing prevents fissures due to mechanical stresses caused by the water pressure and the uneven distribution of the loads on the soil, and closes up again, to some extent, those fissures which have been formed by the contraction of the concrete while setting. In addition, prestressing by compressing the concrete around the piping and casings of the experimental channels improves the hermeticity of these passages through the walls. Finally we think that the absence of fissures contributes to the good performance and long service of the internal lining.

Prestressing

The tank used for MELUSINE, the lining of which was finished during the autumn of 1957, was prestressed according to the system of the Société des Grands Travaux de Marseille. There is a horizontal joint, at the lower part of the side walls, but the vertical walls were poured in one session and make up a solid block. The hermeticity test carefully conducted made it possible to determine that the leakage output as measured, namely 4 litres/day (for a total capacity of approximately

400 cu.m) was close to the error in its measurements.

The prestressing system of the Société Technique pour l'Utilisation de la Précontrainte was used for the lining of the TRITON reactor. The larger dimensions of this unit, allowing in particular for the presence of the adjacent back compartment, led us to provide several sets of joints, both at the floor and on the sides. These, about 10 cm wide, are V-shaped so that, as they fill up they form a wedge under the effect of hydrostatic pressure. This precaution, allowing for the large dimensions of the lining, has the effect of preventing the formation of fissures too large to be closed by prestressing.

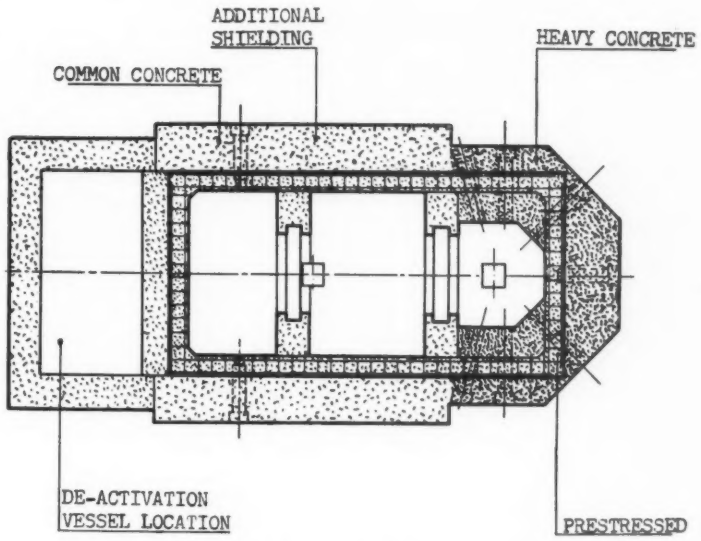
The additional protection of MELUSINE consists of heavy concrete which contains baryta, that of TRITON of common concrete, for the users of this latter reactor accepted longer channels. Its thickness was determined by biological shielding considerations and, even in the area of the channels, greater thicknesses were chosen in order to reduce the background levels of the measuring instruments used by the experimenters.

Weak Points

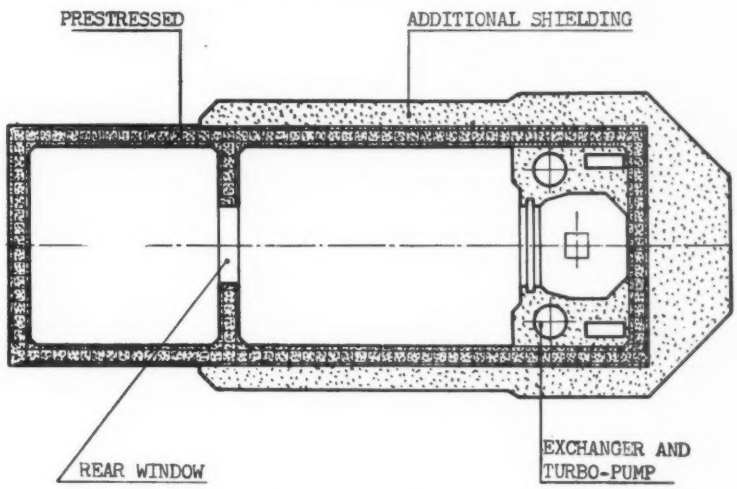
A number of channels feed purified water to the swimming pool to purify the water in a closed circuit, cool it off or drain it. The points where these lines of piping go through the walls can be weak points as regards hermeticity, and this must be studied as carefully as the tightness of the concrete used for the walls.

We have already mentioned that we arranged the window in TRITON not toward the lobby but, rather, toward a small compartment inside the prestressed concrete swimming pool in order that any break in the light plate which covers it should not cause too much lowering of the water level. It is indeed essential to ensure that the core is always bathed in water.

In a similar manner we were concerned that a break in the pipes which go through the walls outside the pool might allow the water to escape. Therefore, all these pipes have been designed so as to go through the wall at as high a level as possible. We arranged the vents at high points in order to unprime any syphons thus formed.



Plan of Melusine Reactor



Plan of Triton Reactor

The largest of these pipes are those of the cooling loop; contrary to our practice with regard to MELUSINE, we have been able to avoid in TRITON the use of pipes which remove from the swimming pool tank the water which has just gone through the core. In fact, we placed all the components of the primary refrigeration loop inside the swimming pool, in such a way that the cooling loops of the two reactors are somewhat different.

A conventional arrangement of cooling loops has been adopted for MELUSINE, the deactivation tank, the pumps and the heat exchangers being outside the swimming pool. The deactivation tank is located in a room, the thick walls of which provide biological shielding, and the connecting pipes between the pool and the above-mentioned tank are lost in the swimming pool concrete.

With regard to TRITON, the deactivation compartment was placed inside the swimming pool under the core in its working position at 1,200 kW, and the heat exchanger and circulation pump were installed inside the swimming pool in a vertical cavity provided for that purpose in the internal concrete filling.

Hydraulic Turbine Used

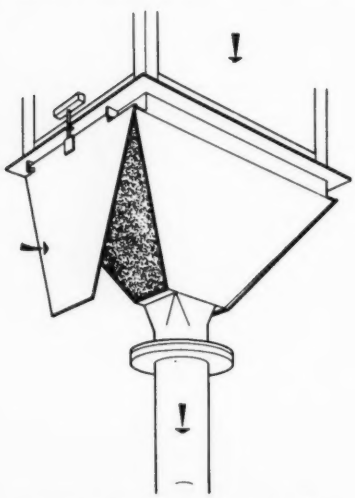
In addition, in order to avoid the necessity of setting up a submerged

electric motor, or to provide for a troublesome engine-pump transmission, and particularly to dispense with all electrical static which would affect measurements, the pump used for water circulation in the swimming pool is driven by a hydraulic turbine actuated by the water of the secondary loops, which goes through the heat exchanger. There is no regulating device for the hydraulic turbine; for the loss of head in it is an increasing function of that very discharge head. The turbo-pump assembly thus acts as a mechanical energy-exchanger between the primary and secondary refrigeration loops. It is installed on the upper part of the heat exchanger. It is submerged and all precautions were taken to avoid any leakage from the raw water circuit to the purified water circuit of the pool.

Refrigeration Check

In addition to the safety factor already mentioned and its simplicity, this device has the advantage of keeping the source of parasitic radiation made up of the active water close to the core. In addition, it provides means of checking the refrigeration by comparing, at a glance, the water level above the exchanger with that in the rest of the swimming pool. A difference between those levels shows that primary water circulates, thus that the turbo-pump works, and that the secondary water which drives the latter also circulates.

Let us finally mention that the two reactors are equipped under the grating on which the core rests, with a device which ensures reliability of core cooling, in case of a circulating-pump breakdown. A part which is shaped like a truncated pyramid serves as a connection between the grating and the suction pipe of the cooling circuit; two sides of this assembly hang from their upper edges and, as they pivot about their hinges, act as check valves. They close when the pump works and open in the opposite case, providing for circulation by natural convection.



Cooling water safety device as used in reactors Melusine and Triton

This device has been developed in the hydraulics laboratories of the Neyrpic Co. of Grenoble on their actual size models and under actual utilization conditions. The transition stages between forced and natural circulation have been carefully studied for, under both systems, water circulates in opposite directions through the core, and there was reason to fear that, on passing from the one to the other, there might be a transient temperature rise which might prove excessive.

In view of the high degree of safety afforded by these reactors, we were tempted to equip them with different power control systems, each of which offered a certain novelty.

In both cases the automatic control device is essentially designed to maintain the power of the reactor constant throughout the experiments, but it also enables the operator to shift from one power level to another, merely by changing the required power as set on a dial.

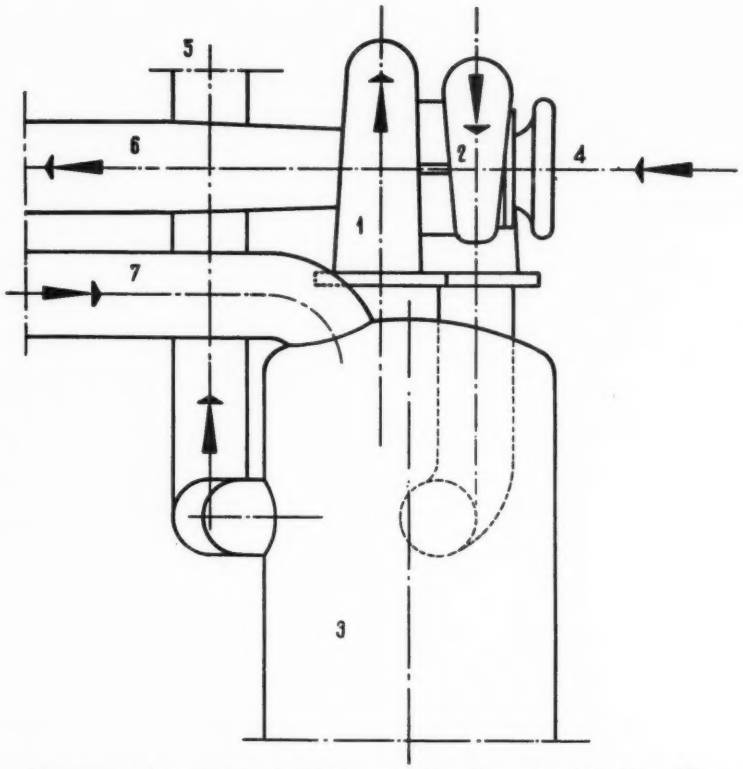
The difference between this required power and that which corresponds to the flux measured by an ionizing chamber is the correction signal which controls rod displacements.

Control Differences

The relationship between the correction signal and rod displacement is not the same for both reactors: this constitutes a fundamental difference between their control devices.

In MELUSINE the servo-mechanisms which control the rods are of the conventional type, namely, they work by determining a speed, or ratio. The rods are moved at a speed proportional to the correction signal.

(*Continued on page 323*)



Arrangement of steam raising and electricity generating equipment attached to Triton.' Key: 1-Turbine; 2-Pump; 3-Exchanger; 4-Suction, primary water; 5-Pumping, primary water; 6-Return, secondary water to turbine; 7-Inlet, secondary water

PEOPLE... in the NUCLEAR NEWS

MR. E. C. SCOTT, BSc(Eng), MIEE, system operation engineer of the North Eastern Division of the Central Electricity Generating Board, has been appointed system operation engineer at the Board's headquarters. Mr. Scott, who is 57 years old, was educated at Dundee High School and later at St. Andrews University. He served a college apprenticeship course with Metropolitan-Vickers Electrical Co., Ltd., becoming a junior engineer in their meter engineering department. In 1928 he was appointed meter superintendent with the Perak River Hydro-Electric Power Co., Perak, F.M.S., and later as assistant control engineer and then system control engineer. Returning to England, he joined the Central Electricity Board, South West England and South Wales Area in 1933 as general assistant, operation department, becoming grid control engineer in 1934. He transferred in 1946 to the operation department at CEB headquarters as area assistant. On April 1st, 1948, Mr. Scott was appointed as the engineer responsible to the system operation engineer at headquarters and held this position until March 1st, 1951, when he acted as personal technical assistant to Sir John Hacking.

One of the very few women ever to become a full member of the Institution of Electrical Engineers has retired from her active working life as an engineer. She is **MISS DOROTHY SMITH,** AssocMCT, who for 43 years has been in the service of Metropolitan-Vickers Electrical Co., Ltd. For most of her career, Miss Smith was in the motor engineering department. A prominent member of the Women's Engineering Society, she was chairman of the Manchester branch from 1943 to 1945 and from 1947 has been a member of the council of the society.

MR. L. ROTHERHAM, MSc, FInstP, FIM, member for research of the Central Electricity Generating Board, has been co-opted to the council of the British Welding Research Association. Mr. Rotherham who was chief metallurgist and director of research and development, of the UKAEA Industrial Group from 1950 to 1958 is a member of the Scientific Advisory Council of the Ministry of Power, and of the general board of the National Physical Laboratory. Earlier this year he was elected a fellow of University College, London.

Following their acquisition of the nuclear engineering and consulting firm of General Nuclear Engineering Corporation, Combustion Engineering Inc., have appointed **DR. WALTER H. ZINN,** vice-president of the company in charge of all their nuclear power activities. Dr. Zinn was formerly head of General Nuclear Engineering Corporation, which he formed after relinquishing the directorship of the Argonne National Laboratory, a post he held from 1946 to 1956. A pioneer in the designing and building of nuclear power reactors, Dr. Zinn supervised under the late Dr. Enrico Fermi the construction of the

Dr W. H. Zinn

world's first nuclear reactor at Stagg Field, Chicago, in 1942. He contributed importantly to the design of the Hanford Production reactors and was responsible for the design and construction of the first heavy water moderated reactor in 1944. During the tenure of his directorship of Argonne in addition to directing activities of the laboratory he undertook the design of a number of reactors including the EBR-I, STR, BORAX, EBWR and EBR-II. More recently, as president of General Nuclear Engineering Corporation he has been engaged in the design of a high temperature gas cooled reactor with heavy water as moderator and also in the study of producing superheated steam with a boiling water reactor. Dr. Zinn is chairman of the review board of the U.S. Atomic Energy Commission's Reactor Handbook, consulting editor for the McGraw-Hill Book Co's series on nuclear engineering, and special consultant to the Joint Congressional Committee on Atomic Energy.

Head Wrightson & Co., Ltd., have announced that the Right Honourable **THE EARL OF HALSBURY,** FRIC, FInstP, has joined the board of Head Wrightson Processes Ltd.

Among appointments recently announced by the Eastern Division of the Central Electricity Generating Board, are those of **MR. C. L. JAQUES,** MIMarE, MInstF, as chief generation engineer, and **MR. P. K. DAVIS,** MIEE, as electrical engineer. Mr. Jaques, who was formerly southern generation engineer of the Eastern Division, started his engineering career as an apprentice marine engineer and served with the New Zealand Shipping Co., Ltd., for six years. After a further six years with British Xylonite Co., Ltd., and then with Clarke, Chapman & Co., he joined Bradford Corporation Electricity Department. In 1938 Mr. Jaques moved to the County of London Electric Supply Co., at Barking and after assisting in the commissioning of Littlebrook "A" station was appointed deputy station superintendent at Barking in 1945. Mr Davis, who started his career in the electricity supply industry in 1932 in Northern Ireland, was previously with the Consulting Engineers firms of G. V. Twiss and Partners and Merz and McLellan.

The Babcock and Wilcox Co. of America, is to be represented in the nuclear field in Europe by **MR. RALPH W. DEUSTER,** who will operate from the company's recently established nuclear sales office in Brussels. Born in 1920 in New Jersey, Mr. Deuster received a BSc degree in mechanical engineering from Purdue University in 1942 and a MSc degree in physics from Princeton University in 1950. He joined B & W in

Mr. R. W. Deuster

1955 as a nuclear systems specialist assigned to sales liaison and two years later became assistant to the manager of the propositions and contracts department. Previously he was employed by the Armour Research Foundation, of Chicago, Illincis, as a project engineer and supervisor.

Formerly commercial manager of the Industrial Group of the U.K. Atomic Energy Authority, **MR. W. P. WARREN,** BSc, MIEE, is now sales director of the Cambrian Wagon and Engineering Co., Ltd., a subsidiary of the Powell Duffryn Ltd. Before joining the UKAEA, Mr. Warren was with Metal Industries Ltd., as general manager of Cantie Switches Ltd. After early training and appointments with the GEC he joined, in 1948, the South Wales Electricity Generating Board, where he became assistant chief commercial engineer in charge of industrial supplies and development through the South Wales Area.

MR. NEILL GIBSON BENNETT, MBE, AFRAes, MIAS, recently elected joint managing director of Graviner Ltd., and formerly chief engineer of their aircraft division, was educated at Glasgow High School and the de Havilland Technical School. His first posts as a licensed aircraft engineer, were with the Scottish Flying Club and Scottish Aviation Ltd. In 1939 he joined the accidents investigation branch of the Air Ministry with whom he stayed until 1946, when he joined Graviner Ltd. He was appointed chief engineer and director of the company of 1947.

MR. D. C. GUNN, BSc(Eng), MSc, AMIMechE, MInstF, has been appointed as chief engineer to Cochran & Co., Annan, Ltd., the boiler makers. Mr. Gunn was formerly deputy director of The British Coal Utilization Research Association.

NUCLEAR ENERGY DEVELOPMENTS IN

SOUTH AMERICA

by J. BURKETT

In most of the countries south of the United States there is an increasing demand for electricity, particularly where the first stages of industrialization are being entered into. Interest in nuclear power is mainly academic with Authorities concerned watching developments elsewhere and awaiting competitive prices, but here and there, where demand for power is most pressing, there may be a potential market for the small nuclear power plant.

MEXICO

IN Mexico interest is being shown in nuclear power applications, particularly in the economics of a 35 MW plant for North Mexico.

In the remainder of Central America: Guatemala, Honduras, Salvador and Panama, fuel for power generation is imported mainly from the Caribbean area. Whilst energy requirements are pressing it is expected that the development of hydro plant will meet foreseeable future demands. Nuclear power will only be of interest, therefore, in remote parts where it will be uneconomic to run transmission lines or if cost can compete with that of future hydro projects.

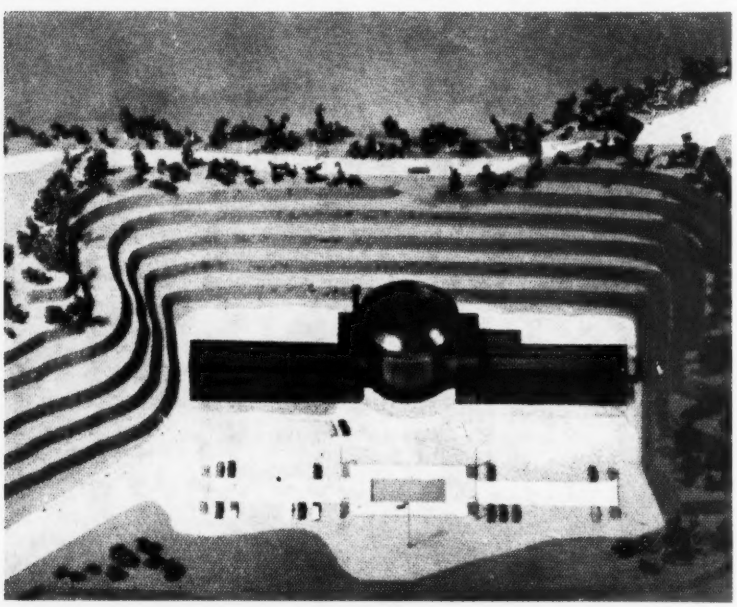
CUBA

THE aim in Cuba appears to be increase of industrial activity and raising the standard of living in the rural agricultural areas. The main industry at the moment is concerned with sugar cane. Most of Cuba's electricity relies on petroleum imported from Venezuela and, with a cost to industrial consumers of 25-30mills., it is not surprising that nuclear power is being investigated as an alternative.

The new bilateral agreement with the U.S.A. enabling Cuba to obtain up to 700 kg of contained uranium-235 enriched up to 20 per cent. is likely to enhance the construction of the 22 MW(e) plant which is the subject of negotiation between Cuba and the Mitchell/AM & F combination. This plant, a pressurized boiling water system for the Pinar del Rio mining area, is planned for start-up by 1961.

VENEZUELA

VENEZUELA is a rich oil producing country where known reserves estimated at 15,000m. barrels are expected to last from 15/20 years. In addition to oil, there is a 10,000 MW hydro potential. Although Venezuela's interest in nuclear power is possibly only academic at the moment, her research programme includes a 3 MW(heat) pool type reactor which is being built by GEC for the Venezuelan Institute for Scientific Research, a materials testing reactor and three 15 MW(e) boiling water reactors. A recent revision of the 1955 agreement with the U.S.A. enables Venezuela to purchase or lease up to 800 kg of fuel for these reactors.



Model of the 3-5 MW pool reactor buildings built for the Venezuelan Institute of Scientific Research by the GEC of America

CHILE

CHILE also has indigenous energy resources in the form of coal and hydro. In addition, imported oil can be easily transported from the coast. There is no need yet for nuclear power but nuclear research is being conducted at the Universities of Chile (at Santiago), Concepcion, and Santa Maria (at Valparaiso).

BRAZIL

BRAZIL is emerging from the status of an undeveloped country to the first stages of industrialization. Economic expansion of recent years has outpassed power capacity which needs an increase of at least 10 per cent. to satisfy the present and future demands. At the present rate of expansion installed capacity required by 1960 will be 5m. kW, 8m. in 1965, 13m. in 1970, and 22m. in 1975. It is a very big country with a vast hydro power, but with poor coal reserves and small petroleum production. The majority of the 60m. population lives in the coastal area but the official policy is to develop the interior in order to open up natural resources.

The future capital, to be named Brasilia, lies inland in the Parana Basin, the richest area for water power with a present capacity of 1,235 MW and a possible maximum potential of 18,000 MW. Apart from hydro development, oil-fired stations for inland locations will be out of the question, because of the prohibitive cost of fuel oil, even if good roads are eventually built.

In spite of the country's vast hydro potential, these resources are often distant from potential markets. The development of hydro power in remote areas is hampered by the high transportation costs of constructional materials and the high transmission costs. Consequently, load centres which are widely separated are oil fuelled and individually operated. Between 1945 and 1955 oil fuel imports increased from 16 per cent. to 41 per cent. of the total energy requirements.

At the new Nuclear Science School in Quito, Ecuador, Dr. Rodrigo Fierro Benitez (*third from left*) discusses an atomic problem with research colleagues. Dr Fierro, trained in Spain, Italy and France, has been appointed a professor in the school, which was established with the aid of the International Co-operation Administration of the United States

Brazil is naturally anxious therefore to avoid building new major conventional stations involving the importation of fuel oil and for the immediate future, on account of the annual foreign exchange burden, hydro projects will be far more economical and should supply the bulk of expanding power requirements for most parts of Brazil. Additional thermal and diesel plants will be needed to complement hydro, particularly in areas without hydro and where power expansion is required urgently.

For the near future, therefore, there is no urgent requirement for nuclear power plants except perhaps at interior locations which lack both transport and convenient fuel resources and/or where high load factors are required. The prospects for nuclear power might increase steadily between 1965-75. If foreign exchange economics no longer predominate by 1975, nuclear reactors may become the principal means of expanding power capacity.

The National Atomic Energy Commission set up in November, 1956, has drawn up a preliminary programme, although generally speaking, however, the long-term programme is not yet clearly defined. As part of the training programme a 5 MW swimming pool research reactor is in operation at the Sao Paulo Nuclear Energy Institute, and a 30 kW " TRIGA " reactor of General Dynamics Corporation is being ordered for the Minas Gerais University at Belo Horizonte. An Argonaut type research reactor is to be built for the University of Brazil in Rio de Janeiro.

Proposals have been made for a 10 MW(e) reactor for the State of Rio de Janeiro and a 15-20 MW(e) boiling water reactor for COPEN (Companhia Paulista de Energia) to be built near Sao Paulo. This is intended for the training of operators for a 150 MW plant of the same type to be built at Rio de Janeiro.

The preliminary programme of the Commission also included several nuclear stations of 10-100 MW capacity for certain remote and independent supply centres, and the installation of various small-scale units (1-10 MW, dependent on competitive cost) in isolated regions and where at present small diesel or petrol units are being used. The hydro-electric plant that is being constructed for the new capital Brasilia is not expected to be completed in time for the inauguration in 1960. Discussions are being conducted by the Brazilian authorities with the Mitchell Engineering Co./AM & F Atomics on the possibility of supplying a 20 MW boiling water reactor for the interim period after which it could be transferred elsewhere when it was no longer needed.

Further details can be obtained from the following papers presented at the 2nd International Conference on the Peaceful Uses of Atomic Energy:—P/2257—On the training of personnel for atomic energy, etc.; P/2274—Description of the Brazilian research reactor; and P/2279—Preliminary results of 5 MW operation with the Brazilian swimming pool reactor.

URUGUAY

IN Uruguay where there is no local fuel reserve and only limited hydro potential, there is a pressing need for a new energy source. At the moment electricity supply comes from a vast network of transmission lines fed mainly from the Runcon del Boneta hydro station on the Rio Negro, supplemented by thermal plants in Montevideo. The interest in nuclear power plant is likely to lie in alternatives to 100 MW conventional plant.

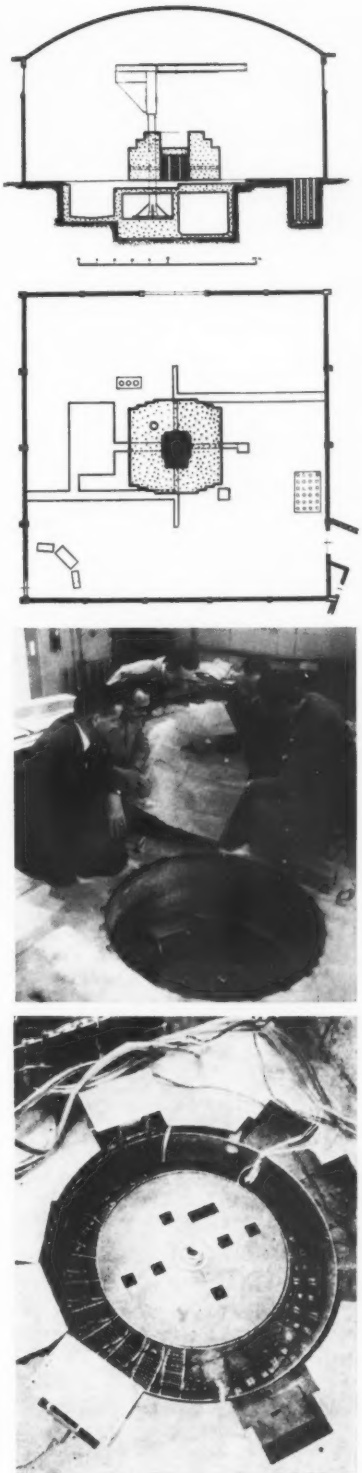
Further details can be obtained from the following paper presented at the 2nd International Conference on the Peaceful Uses of Atomic Energy:—P/1527—Production of electricity from nuclear sources within the next 25 years.

ARGENTINE

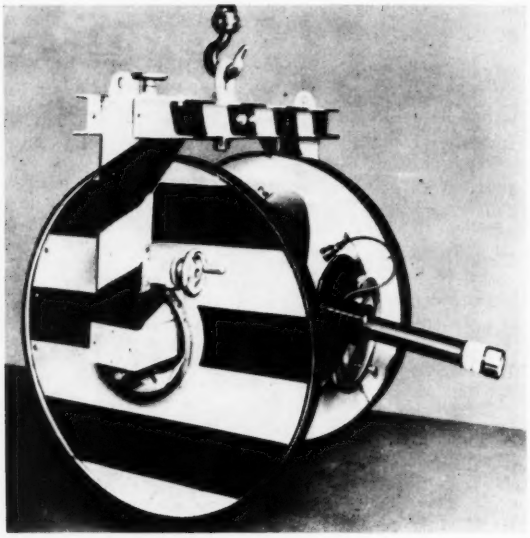
FUTURE demands for energy in the Argentine are likely to be met by indigenous fuel resources with the possible exception of the central and eastern regions. It is suggested that 2,000 MW of nuclear power capacity by 1980 might be justified in these areas.

The National Atomic Energy Commission set up in 1950 has now in operation an Argonaut research reactor, RA-1, and a pilot plant for the production of metallic uranium. It is planned to use the local uranium for a 150 MW station near Buenos Aires.

Further details can be obtained from the following papers presented at the 2nd International Conference on the Peaceful Uses of Atomic Energy:—P/1584—Construction and start-up operations of the first Argentine reactor (RA-1); and P/1585—The manufacture of fuel elements of the Argonaut type.



The National Atomic Energy Commission of Argentine has in operation an Argonaut research reactor RA-1. These illustrations show (*top*) section and plan of the reactor buildings (*centre*) scientists discussing the reactor construction and (*below*) core of the reactor



High Intensity Co Container for Industrial Radiography

Newton Victor Ltd., the X-ray department of Metropolitan-Vickers Electrical Co., Ltd., has recently supplied a cobalt container which, with a source of 1,500 curies, is believed to be the most powerful in industrial use in the world. The container was taken to the Atomic Energy Establishment, Harwell, for the fitting of the cobalt 60 source. From there it was transported by road to the Darlington factory of Whessoe Ltd., to be housed in a specially constructed concrete building and used for the radiographic examination of welded seams in steel plate up to 5 in. thick.

THE Newton Victor industrial cobalt container is the outcome of a number of years of experience with its medical counterpart. It is particularly suitable for work on large construction sites, especially if these are located in remote areas, as in addition to its inherent reliability it is largely independent of electrical and water supplies. Small currents are necessary for control purposes, but the quality of the radiograph is not dependent on the maintenance of precise voltages and frequencies. No water or oil cooling is necessary, and ambient temperatures up to 150°F. will not influence the operation of the container.

The protective container is housed in a steel cylinder which can be rolled on its heavy steel end-flanges over rough ground. A steel supporting fork is provided for slinging the unit from a crane or, with the angulating gear disengaged, for hauling the equipment up a loading ramp on to a vehicle. The unit is provided with 200 yd of interconnecting cable.

Through All Angles

A worm wheel drive fitted to the fork is used to angulate the container, and thereby the beam of radiation, through 350°.

Thus, when supported by a crane or other suitable mounting, the container can be rotated about both horizontal and vertical axes and this is of particular value in the examination of spherical and cylindrical pressure vessels. The worm drive may be disengaged when the container is being moved to a new site.

The cobalt source is housed in a lead and heavy alloy protective container thick enough to reduce the intensity of the radiation at the surface to 6.25 milli-roentgens/hr with a source of 1,500 curies.

Wear Problem

In some systems the source is moved manually from the " protected " to the " exposure " position, and this is liable to involve friction and adhesion problems, as minimum clearances are necessary to avoid radiation leakages along the joints of the sliding arrangement. In the Newton Victor unit, the source is housed at the periphery of a disc which moves through 180° from the " protected " to the " exposure " position. Adequate clearances are possible without any loss of protection, as the source wheel is, in all positions, totally surrounded by the lead and heavy metal protective shield. The source wheel is driven by a motor against a mechanical stop, eliminating the wear and inaccuracy of latching contacts. A magnetic clutch between the motor and the source wheel ensures its immediate return by means of a lightly loaded spring if the electricity supply is interrupted.

Interchangeable diaphragms of tungsten copper alloy provide a beam of radiation 6 in. or 12 in. wide × 5 ft long (15 cm or 30 cm × 150 cm) at a distance of 12 ft (360 cm) from the source.

Source Positioning

During the setting up of the container, a simple but powerful light projector is used to indicate the position of the beam on the specimen at distances up to 20 ft (600 cm). The light, in the form of a cross, indicates the exact position of the centre of the beam of gamma radiation. When not in use the projector may be swung out of the way, or, for transportation, completely detached.

The sheet steel control box for wall or desk mounting is 20 in. long × 12 in. wide × 11 in. deep (51 cm × 30 cm × 28 cm) and includes the exposure timer, shutter control, signal lamps, master switch with removable key, and 150 ft (45 m) of 3-core cable.

An Exposure

An exposure is initiated by pressing a button; the source moves from the " protected " to the " exposure " position and starts the synchronous motor timer which has a range of one second to 55 min in steps of one second. Signal lamps indicate the position of the source at all times; these red, green and amber

lights are energized at a low voltage to show that all three lamps are in order. As one lamp at a time is energized at the full voltage, it indicates the position of the source; green indicates the source in the " protected position," amber the source moving from one position to the other, and red the source in the " exposure " position.

Four Signal Lamps

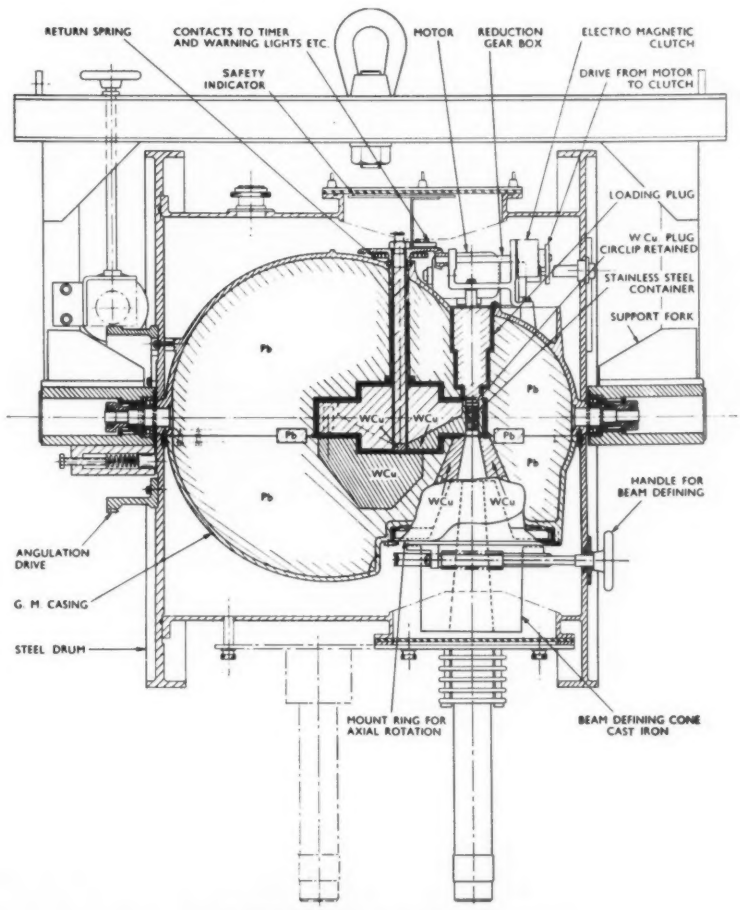
Four red lamps on the container itself are also energized when the source is in the " exposure " position.

All signal lamps may, in the event of power failure, be operated by long-life batteries included in the control system.

As described above, operator protection is assured while moving the source to the " exposure " position. Having positioned the container and adjusted the beam to the desired part of the welded structure, the operator fixes the film or cassette on the remote side and then returns to the control, which may be 100 ft (30 m) or more away. Alternatively, a concrete wall from 9 in. (23 cm) to 36 in. (90 cm) thick may be used to provide the requisite protection.

Automatic Return

On reaching the control the operator sets the exposure timer and presses a button which brings the source from the " protected " to the " exposure " position. At the end of the pre-set period the source is automatically brought back to the " protected " position; this also happens if at any time the electricity supply is interrupted. Additional signals and interlocking relays to prevent unauthorized entry to the exposure area can be easily connected to the control. Operators can, therefore, work continuously with this container without any risk of receiving an excessive dose of radiation.



Sectional drawing of source container

DOUNREAY

Electricity Supply

(*Continued from page 309*)

the speed of adjustment of the regulators is limited by a gearing system and the maximum speed of its driving motor.

The 415v auxiliary essential-load switchboard has a 1 MVA Grid connection, and supplies trace heating circuits, lighting and power for the diesel house, sea-water pump house, etc.

A 240v, 800 Ah battery with rectifier connections to the 415v essential-auxiliary board has been provided. This supplies governor control and voltage regulators in the diesel house, emergency lighting and various cooling fan drives. It also feeds instrumentation control shut-off and safety-rod drives, via motor-alternator sets.

Flux Control

Control of the neutron flux, and therefore the heat generated in the reactor, is effected by moving groups of fuel elements into and out of the core, the former movement giving increased reactivity. Drives for the rods are by induction motors through special transmission and linkage controlled by limit switches. Since the motors are required to work in an ambient temperature of approximately 150°C., they have class-H insulation and all cables are mineral insulated with high-temperature seals.

A 15 MW turbo-alternator set is being installed to utilize the heat from the heat-exchangers, but this is likely to operate only experimentally and intermittently for some time. Owing to the isolated location and the long supply lines, special problems of stability may arise and limit the amount of power export possible, particularly at times of light load in the Thurso area.

LAB. extended

RADIOISOTOPES play an important part in the new research laboratories of Wakefield-Dick at Hayes, Middx., where they are used for testing the efficiency of the company's products. Volume of research and development work at the laboratories has increased three fold over the past ten years and a large extension was recently added to the existing buildings to accommodate the extra work.

'NUCLEARIST' writes . . .

WAS I being grossly unfair when I earlier accused the British authorities of tardiness in introducing nuclear education more extensively into schools and colleges? I think not, indeed, and in fact, other people appear to agree wholeheartedly with me. For instance, Dr. H. F. Boulind, of the Education Department, Cambridge University, claims that school physics and chemistry long ago stopped at 1900, or even 1800, and that it is time we entered the twentieth century. Writing in the *School Science Review*, he confirms what I said earlier, that atomic science is not so difficult that it must be dismissed out of hand, especially when it intimately concerns us all. He proposes a school syllabus covering the evidence for the existence of molecules, atoms and electrons, atomic structures and their uses, atomic energy and its applications, its dangers and control, and moral implications. He puts in a plea for research into the design of simple and effective demonstrations and experiments suitable for schools, suggestions and short courses for teachers, exhibitions and demonstrations, and a suitable textbook. Dr. Boulind calls upon UNESCO to initiate and encourage these steps. This is an excellent idea, but it is still shocking that our own educationalists cannot do something themselves.

* * *

I expect the American alarmists are getting very worried about the threats which may be implied by the opening-up of the northern sea routes by Soviet shipping. The world's first nuclear-powered surface ship, the ice-breaker "*Lenin*," will soon be sent by its 44,000 h.p. motors to the frozen wastes of the Arctic, now that its trials are over. By keeping the northern passages open, it can shorten the distance between Murmansk and Vladivostok by nearly 6,000 miles, and it is estimated that during the next six years shipping in that part of the world will increase by 32 per cent.

But even the Russians have their nuclear setbacks, if we may believe the Austrian press report of a serious accident in an atomic power station near Sverdlovsk. It seems that radioactivity was scattered over an area of 5,000 sq.miles, necessitating the evacuation of 12 villages and several communal farms. There were 172 cases of radiation sickness, and 20 people were blinded. It remains to be seen, of course, whether the Russian authorities will release full information, which would be very helpful to other nations. Whether genetic damage will also result is another matter which only time can decide.

* * *

Genetic studies, incidentally, have attracted a great deal of attention in Germany. Results from two major universities, covering the period 1950 onwards, indicate that the effects of small doses of radiation cannot be statistically determined from deformations occurring in human embryos. Deformations are of very varied origin, and may result from damage to the embryo in the uterus as well as gene damage. Exceptionally marked changes may occur as a result of the fusion of male and female germ cells when both have been genetically damaged. Only the gamma component of bomb fall-out appears to have an effect. In Germany, no complete picture of deformations is yet possible, since partial results are not representative, and there is no documentary evidence of the causes of stillbirths and miscarriages. The frequency of such occurrences increased since 1910, but has decreased again since World War II. The overall picture suggests that radioactivity cannot be a determining factor in deformations—it may perhaps have a smaller but more lasting effect than other causative agents, but the present state of knowledge does not permit the possibility of reaching conclusive decisions.

* * *

Of course, geneticists in Germany are a little uncertain of themselves since Nazi days, or at least, uncertain how the world will accept their opinions. Up until the Second World War, the German Society for Genetic Science, founded in 1921, was the official body which combined all genetic research, and its activities extended into biology, medicine, physics, etc. This society was silenced, however, by the ghastly misuse of genetics in the establishment of the Nazi racial policy. A few of the stalwarts remained faithful however, and continued their work in secret, and their work gained for them respect abroad. It is largely due to these scientists, then, that the suggestion was made at Montreal recently, that the next international genetics meeting should be held in Germany. The society is now passing through the birth throes, and doubtless will soon be welcomed and revered throughout the world once more. This should put an end to the inhibitions which have dogged its members since Hitler's time.

* * *

In the MacMaster University, Hamilton, Ontario, the first Canadian privately-owned research reactor has gone into operation. This was built by the American firm, AMF Atomics. Although having plenty of nuclear developments on its plate at home, Canada can still find time to help people overseas. The Canadian-Indian reactor, when it comes into operation, will be one of the world's largest isotope producers. This will be India's third reactor. Mr. Nehru certainly "debunked" a questioner who asked whether there was any real need for the second Indian reactor, by stating that not only would India have this second reactor, but many others also. When the Department of Atomic Energy asked for its latest allocation of £7½m. (or 100m. rupees), the whole sum was granted after only 90 min of discussion. The government is obviously keenly aware of the importance of the Indian atomic programme, and does not intend to discourage it. Only five or six countries in the world, it is estimated, can be said to be ahead of India in nuclear progress and we may expect great things from this huge nation which has so long been in the technological backwoods.

* * *

The fanfare given to the official opening of Calder Hall was not repeated for the opening of Chapelcross. There was a quiet, almost parochial air about the occasion, which in the circumstances was up to a degree warranted. All the same it would have done no harm if the world had been reminded of Britain's lead in nuclear matters a little more forcibly.

NUCLEAR NEWS

- **U.K.'s N-Powered Ship** *(This page)*
- **Reactor in Five Models** *(Page 320)*
- **I.A.E.A. Missions** *(Page 321)*

PLANS for Britain's first nuclear powered merchant ship have been submitted to the Admiralty for technical, safety and financial consideration by eight different firms and organizations. These are the AEI-John Thompson Nuclear Engineering Co., Ltd., who have submitted proposals utilizing a direct cycle natural circulation boiling water reactor system; Babcock & Wilcox, Ltd., a pressurized water reactor system; De Havilland Engine Co., Ltd., high temperature gas-cooled reactor system; General Electric Atomic Energy Group, gas-cooled graphite moderated system; Hawker Siddeley Nuclear Power Co., Ltd., organic liquid moderated reactor system; Mitchell Engineering, Ltd., and the Fairfield Shipbuilding & Engineering Co., Ltd., closed cycle boiling water reactor system; the UKAEA, advanced gas-cooled reactor system; and Vickers Nuclear Engineering Group, steam-cooled heavy water reactor system. The proposals will be studied to see which offers the best advantages against how soon it can be put into service. The Atomic Energy Authority and the Ministry of Transport and Civil Aviation will consider their safety aspects; a special sub-committee of the Civil Lords Committee will investigate them from a technical angle; while the Civil Lords Committee will investigate means of financing the first ship.

I.A.E.A. Austrian Lab.

THE International Atomic Energy Agency is to set up a functional laboratory on a site adjoining the Austrian reactor and atomic laboratories at Seibersdorf, near Vienna. The U.S.A. is to donate $600,000 to be applied against the cost of constructing and equipping this laboratory. The Netherlands are prepared to contribute a gamma-spectrometer worth approximately $2,500. The laboratory will serve for the standardization of isotopes and preparation of radioactive standards; calibration and adaptation of measuring equipment; quality control of special materials for nuclear technology; measurements and analysis in connection with the Agency's safeguards and health and safety programme and services for member states.

Bomb Industry?

A MULTI-MILLION dollar industry for the production of atom bombs for industrial use in Canada might well spring from nuclear experiments being planned by Richfield Oil Corporation of Los Angeles, in Northern Alberta early next year, the Canadian House of Commons mines committee were recently told. Dr. J. Convey, director of the mines branch of the Canadian Department of Mines and Technical Surveys, explaining the experiments, said that if they were successful it would take nearly 11m. bombs to separate the oil from the sands in the 17,000 sq.mile area of Athabasca tar sands. This would mean that one small bomb of the 10-kiloton variety—the equivalent of 10,000 tons of TNT—would be required for each acre of ground.

S.A. Nuclear Future

MR. A. J. STROUD, former United Kingdom Trade Commissioner in Johannesburg, has raised the possibility that Britain may supply South Africa with a nuclear power station in the not too distant future. He considers there are two reasonably short-term prospects of Britain exporting a nuclear power plant to South Africa: the possibility of providing such a plant for Escom, and the possibility of providing the South African authorities with a research reactor. He says that roughly three-quarters of South Africa's economic activity is located on or close to the Transvaal coalfields where Escom is selling electricity, produced by conventional methods, at prices well below those achieved, or likely to be achieved, at the nuclear power stations in operation, or under construction, in the United Kingdom. In the Cape Province, however, it costs Escom more to produce electricity than it costs Britain to produce it at Calder Hall, which is not Britain's most up-to-date power station. Mr. Stroud maintains that if British firms could provide 30 to 60 MW nuclear power reactors capable of producing cheap electricity when operated at relatively low load factors, there would undoubtedly be a market for them in those areas of South Africa which are remote from the coalfields.

Another Jap Group

THE sixth nuclear energy group in Japan is about to be formed, with the Meidensha Electric Manufacturing Co. as the leading member. Other member companies will be C. Itoh Co., Nippei Sangyo Co., Uraga Dock Co., Yamatake-Honeywell, and the Kimura Lead and Iron Manufacturing Co. The aim of the group will be to produce chiefly research and training reactors and instruments. It is expected to join in the bidding for the construction of the Japan Atomic Energy Research Institute's gas-cooled solid homogeneous reactor. Nuclear power groups already established in Japan are the Mitsui, Sumiton and Daiichi groups, the Mitsubishi Atomic Power Industries and the Tokyo Atomic Industry Consortium.

Italian Project Contract

Mr. W. E. Knox (*right*), president of Westinghouse Electric International Co., New York, and Dr. G. Franco Castelli, vice-president of Societa Ellettronucleare Italiana (SELNI), who recently signed a definitive contract for the supply of a Westinghouse 160 MW nuclear steam generating plant for the Enrico Fermi nuclear power project to be located in Northern Italy

Five Model Reactors

BELIEVED to be unique in the field of nuclear equipment is the Hawker Siddeley Nuclear Power Co.'s plan to make their research reactor JASON available in five models. These will differ in power output and operating and research facilities. The core components and internal and external reflectors, however, will be identical in all models, thus enabling the owner of even Model 1 to modify it according to his requirements. Model 1 will be a reactor of 1 to 100w, having five irradiation points in the central thermal column and beam holes externally as required by the client. This form of the reactor will be ideally suited for driving internal exponential experiments, oscillator experiments, production of short-lived isotopes and activation analysis. The maximum thermal flux will be between 1.5×10^7 to 1.5×10^9, depending upon the reactor power. Model 2 will be a reactor of 1 to 10 kW, having internal and external thermal columns and two beam holes giving a total of 21 irradiation ports. This model will increase the quantity and extend the range of analyses, etc., which can be performed with reactor 1. The third model will be a standard 10 kW (continuous) reactor with internal and external thermal column and a shield tank, as described in NUCLEAR ENERGY ENGINEER, April, 1958 (page 210). Model 4 will also be a 10 kW (continuous) "Jason," with one internal and two external thermal columns. This reactor will be used for driving two external exponential experiments or for applications where there is a requirement for a large irradiation volume for activation analysis, isotope production or oil, grease and plastic irradiations, etc. "Jason" Model 5 will be provided with a 10 in. beam hole for neutron therapy studies giving an average thermal flux of 8×10^8 n/cm²/sec across the beam hole with the reactor operating at 10 kW. Such a reactor would normally be provided with internal and one or two external thermal columns. A zone of higher flux could be incorporated in the reactor by the installation of a central heavy water irradiation space. This would increase the available thermal flux at any given power by a factor of 1.5 to 2 and offer a region of highly thermalized flux. All these reactors could also be operated for limited periods at powers in excess of the continuous rating.

Plymouth N-Centre

PLANNED to be the leading centre in south-west England for the training of engineers and scientists in nuclear energy subjects is Plymouth Technical College's nuclear laboratory. Over £20,000 will be spent on equipping the building, which is expected to be ready in two years' time. An important item of equipment will be a £7,000 electron microscope.

X-ray Talks

A CONFERENCE on X-ray diffraction and spectrography will be held in conjunction with the Department of Chemistry at Imperial College of Science and Technology, London, S.W.7, from Monday, July 6th to Friday, July 10th. Modern techniques and instrumentation for diffractometry and fluorescent analysis will be discussed and evaluated and an extensive range of modern equipment will be available for demonstrating the principles of these methods over a wide field of applications. Time will be made available for the consideration and study of samples submitted by members. Full information concerning the conference together with details of the registration fees may be obtained from the conference secretary at Research and Control Instruments, Ltd., Instrument House, 207, Kings Cross Road, W.C.1.

C.E.G.B. Show

AN exhibition was recently held by the Central Electricity Generating Board at Thornbury, Gloucestershire, in connection with their application to build a nuclear power station at nearby Oldbury-on-Severn and with their investigations of three other sites in the area for possible nuclear power development. Models of power stations under construction were shown and the principles of nuclear fission were explained by means of drawings and films. The exhibition was opened by Sir Algar Howard, deputy-lieutenant of Gloucestershire.

School Assembly

Dr. John R. Dunning, dean of Columbia University's School of Engineering, and Dr. Edward F. Leonard, assistant professor of chemical engineering, with the school's new sub-critical uranium graphite assembly

Production Day

LORD HALSBURY, president of the Institution of Production Engineers, will open this year's one-day conference of engineers and others concerned with the application of standards in industry. The conference—the fifth of its kind—will be held on Thursday, June 4th, at the Connaught Rooms, London. Theme of the morning session at the conference will be the significance of standards in the national economy, their application in the individual company and the place and function in the company of the standards engineer. At the afternoon session speakers from the IPE and the BSI will report on the significant trends of their work as it affects standards engineers.

Britain in U.S.A.

SPACE can now be booked for the British Exhibition—U.S.A., 1960, to be held in the Coliseum Building, New York City, from June 10th to 26th, 1960. All goods exhibited must have been produced or manufactured in the United Kingdom, with the exception of goods made in North America under licence to British patents, designs or formulae, which will be displayed in a special section. Over 390,000 sq.ft of space is available in the Coliseum, which is equipped with all modern services and special fixture hanging devices. The exhibition, which is to be organized by the Federation of British Industries through its subsidiary, British Overseas Fairs, Ltd., has the full support of the British Government, the Dollar Exports Council, and the British-American Chamber of Commerce in New York.

Exhibition Success

A popular stand at the recent Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia was that of Princes Press, Ltd., publishers of NUCLEAR ENERGY ENGINEER. **During the 15 days the show was open the stand was visited by a continuous flow of engineers, scientists, teachers, businessmen, students and schoolboys**

World Missions

THE Board of Governors of the International Atomic Energy Agency has approved the sending of 10 experts to Burma, Greece and the United Arab Republic and the supply of some equipment to the two former countries. It has also decided to despatch preliminary assistance missions to a group of Far Eastern countries and to three countries in Latin America; in addition, a nuclear power survey mission will be sent to Argentina and Brazil. Three experts will go to Burma. One of them—an expert on uranium and thorium—will visit the country for a six-month period beginning October/November of this year, another—an expert on the medical uses of radioisotopes—will go in April, 1960, for a period of one year, while the third—a specialist on the use of radioisotopes in agriculture—will visit Burma for one year beginning next January. The Agency will also provide Burma with apparatus to equip a laboratory for the use of radioisotopes in agriculture and medicine at an estimated cost of $7,000. The Agency is sending four experts to Greece; their fields of specialization cover health physics, the medical applications of radioisotopes, reactor research and radiobiology. Under the same project the Agency will supply the Atomic Energy Commission of Greece with maintenance equipment of a total value of about $5,200. Three IAEA experts on the uses of radioisotopes will be sent to the National Isotope Centre in Cairo. A preliminary assistance mission is visiting China, Korea, Philippines, Japan and Viet-Nam and another similar mission will be sent to Argentina, Brazil and Venezuela in June or July. In Argentina the mission will advise the country's authorities on the prospecting, mining and processing of uranium ores. Brazilian authorities are interested in receiving advice on all aspects of their nuclear energy programme, whereas in Venezuela the Agency's mission, apart from giving general advice on the setting up of an Atomic Energy Commission and the initiation of an atomic energy programme, will give particular consideration to the development of programmes in connection with the research reactor of Venezuela. Yet another mission of the Agency will survey the possibilities of the economic production and utilization of nuclear power at specific locations in Argentina and Brazil. It is intended to despatch this mission during the second half of 1959.

Detection Service

GLASGOW Corporation is to consider the setting up of a monitoring service to detect radioactivity in the air, water, milk and sewage of the city. Speaking at a recent meeting in Glasgow, Councillor J. B. Vallance, convenor of the Health and Welfare Committee, said that at present there was no Scottish centre engaged on this work. It remained to be determined how the service would be set up, whether in co-operation with other authorities, or in association with the universities or the regional physics laboratories. One centre would suffice for the whole of Scotland and it was possible that Glasgow would take a lead in this matter. The city's Medical Officer of Health would attend a meeting shortly, along with the Regional Hospital Board, the regional physicist, the chief constable and the firemaster. They would discuss the type of information needed by the local authorities, the additional training which would become necessary for personnel in the various departments and the general arrangements for a monitoring service. This move follows recent incidents in Scotland when radioactive materials used in industry were dumped and inadvertently contaminated three boys very slightly.

One of the 12 control rods of the 12 MW pressurized water reactor being built by Westinghouse Electric Corporation for the Centre d'Etude de l'Energie Nucleaire, Mol, Belgium. The operating portion of the mechanism is in the form of a stack of magnetic coils, part of which can be seen here extending halfway up the unit. The coils lift or lower the control rod through a series of steps until the rod is either withdrawn or inserted the required amount

Reactor Control Rod

New Marine Group

A CONSORTIUM of three companies, two British and one American, announced recently that they have designed a nuclear propulsion system for ships. They are Mitchell Engineering, Ltd., of London, the Fairfield Shipbuilding & Engineering Co., Ltd., of Glasgow, and Combustion Engineering, Inc., of New York. The consortium's system is based on a boiling water type nuclear reactor which is available in two versions giving outputs of 25,000 and 50,000 s.h.p. The smaller unit will be sufficient to propel a cargo vessel of up to 100,000 tons displacement. Two of the larger units would propel a large liner. This system is one of the eight now being considered by the Admiralty for adoption in Britain's first nuclear powered merchant ship. The consortium say that their propulsion system could be available for seagoing trials in 36 months from the word "go." Although such a nuclear propulsion system would cost more initially than conventional propulsion machinery, the savings in fuel cost would be such that the use of such a system becomes a commercial proposition for powerful ships. Fuel costs for the new system would be lower than for a conventional marine propulsion unit and they will get progressively less over the next 10 years. The proposed nuclear propulsion unit includes the reactor, specially designed turbines and gears and many other novel technical features. The consortium's design also means that for the first time marine turbines will incorporate re-heat by nuclear means. Patents have been taken out for all these features. Mitchell Engineering, Ltd., have been prominent in the nuclear field for some time past and have designed nuclear power stations on the boiling water reactor principle and are also the originators of the project to ship iron ore from Canada to Britain in giant nuclear-powered submarines which will be able to work all the year round regardless of ice conditions. The Fairfield Shipbuilding & Engineering Co., Ltd., are one of the best-known of Clydeside shipbuilders and have built many of the Royal Navy's most famous ships including *HMS Renown, Valiant, Howe, Implacable*, etc. They were also the builders of the new *Empress of Britain*, one of the country's most modern liners. Combustion Engineering, Inc., has supplied nuclear reactors to the United States Navy for use in American nuclear submarines.

In Mid-America

PUERTO RICO Nuclear Centre recently took delivery of a 10w solution type laboratory reactor by Atomics International Inc., of Canoga Park, California. Established in 1957 to develop a programme of research and training in nuclear science and engineering and in the peaceful applications of nuclear energy in medicine, agriculture and industry, the centre is operated by the University of Puerto Rico for the U.S. Atomic Energy Commission.

Equipment and Materials

Items published in this special feature are compiled from manufacturers' current literature. Readers requiring further information should use the form at bottom of the page. Manufacturers are invited to send literature or details of their products for inclusion in this feature.

85—78 per cent. Efficiency

Efficiency of the new Vokes Fibreglass air filters with 5 micron size particles is approximately 85 per cent. when the filter is clean and 78 per cent. when it becomes loaded up to a pressure differential of 0.5 in. w.g. With 18 micron size particles the initial efficiency is about 80 per cent., reducing to 50 per cent. These filters have a wide application, particularly as pre-filters for prolonging the life of more expensive and efficient types. Of robust construction, and with the maximum possible surface area of fibre and low binder content, the filters are specifically designed to meet the particular demand for inexpensive throw-away types. **(JE 1).**

Valve Range

Heavy-duty pneumatic control valves recently introduced by Martonair Ltd., are made in both three-port and five-port form, in $\frac{1}{4}$ in. BSP, $\frac{3}{4}$ in. BSP and 1 in. BSP sizes. The four operating mechanisms —single pressure with air return, double pressure, lever with air return and three-position lever—are interchangeable between themselves and between different sizes of body. The minimum number of components has been used throughout, and a high degree of reliability is claimed. The valves are of rugged construction, and their robustness makes them suitable for use in conjunction with heavy duty cylinders in arduous conditions. **(JE 2).**

Pulse Analyser

Developed at the Airport Works of Marshall of Cambridge, under licence from the National Research Development Corporation, the Marshall pulse height analyser is designed to exhibit all the characteristics of existing analysers at a fraction of the cost but retaining their accuracy and achieving the utmost in reliability. It is based on the Hutchinson-Scarrott principle, using computer techniques for the storage of information performed in serial manner using two torsional acoustic delay lines. This system is inherently simpler in construction and less extravagant in components than the core memory type of analyser. The facilities of the new analyser include a visual display and automatic readouts in both analogue and digital systems. The analyser will accept a wide range of pulses of either sign up to a maximum mean counting rate of 1,600 pulses/sec. The input pulses may be back biased at the input to the amplifier, when a gate is provided for coincidence and anti-coincidence work. The memory is divided into either 100 or 150 channels for which the energy scale may be either linear or exponential, the latter case giving greater resolution at the lower energy end of a spectrum. Another extremely useful facility is the ability of the instrument to subtract counts from a spectrum already in the memory. In conjunction with the live time integrator, which is necessary at a high counting rate, the background count can automatically be subtracted from a spectrum, leaving the true count in the memory. A total count scaler records the total number of pulses analysed. **(JE 3).**

Mercuryless Meter

Recently introduced by Foxboro-Yoxall Ltd., is a new mercuryless meter to measure a range of differential pressures from 20 in. to 200 in. of water at static pressures up to 2,000 lb/sq.in. Among its design features are a frictionless flexure-pivoted unit of exceptional sensitivity; positive protection against overrange with no zero shift; a simple method of range change; a built-in temperature compensation for all differential ranges and full range damping which is adjustable under pressure. An entirely new and flexible diaphragm assembly is used

Cut along here

To: NUCLEAR ENERGY ENGINEER
147 Victoria Street, London, S.W.1

Please send further details of the following items in the EQUIPMENT and MATERIALS *feature for June, 1959*

Item No's ....

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for the measurement of differential pressure. Preformed discs are welded by a special process and shaped to nest into the adjacent disc and each is welded to a spacing ring. Excess pressure in either chamber will compress the diaphragm assembly until each pair of discs is nested and the spacing rings have contacted to form a metal to metal stop. The drive unit is of solid rods joined by a metal flexure and forms a direct connection between the diaphragm assembly and the pen lever. The fulcrum is formed of two similar flexures and the seal is a flexible bellows capable of withstanding pressures 50 per cent. above the meter rating. This drive transmits the smallest measurement changes to the pen with extreme accuracy. The special range spring, the temperature compensator and the damping valve are exclusive Foxboro features and make the new Type 37 an exceptionally reliable and accurate mercuryless meter. **(JE 4).**

Radiation Proof

The sound insulation and nuclear protection division of Chatwood-Milner Ltd., is responsible for the design and manufacture of special air lock and soundproof doors for the aircraft industry, doors for nuclear energy projects when radiation shielding is required and in addition, blast-resistant doors for defence installations. Chatwood have designed and manufactured sound insulation doors for test bed cells for famous jet engines such as the Proteus, Olympia, Avon and Sapphire and the company is actively engaged in supplying handling equipment for radioactive material and all types of mechanical units for the UKAEA. **(JE 5).**

Magnetic Clarifiers

Now available from stock is a new range of Philips coolant clarifiers, the heart of which is a magnetic drum of unique design called the " Magna-Drum." As a result of the development by Philips of ceramic magnetic materials, it has become possible to produce a drum which is highly magnetic over its entire surface—a distinct advance upon conventional drums which normally use horseshoe type magnets cast in steel and encased in a non-ferrous cylinder. **(JE 6).**

TWO POOL REACTORS

(*Continued from page 312*)

As is well known, the reacting is proportional to the power level at which it operates. In order to have a constant loop reactivity at all levels and, therefore, a constant output, particularly a constant stability, over the whole operational range, it is essential that another unit of the loop have a reactivity inversely proportional to the power level. This is achieved in MELUSINE by making a comparison of the desired power with the measured power, on a logarithmic scale.

The rod-drive control-signal then is of the form: $\log n_0 - \log n$, n being the neutron density in the core.

It is also known that the reactor acts as an integrator. The fact that it is controlled by another integrator (the drive of the rods at a given speed is, in effect, an integrator) may be a cause of instability.

Drawback Eliminated

In order to eliminate this drawback, a known device consists of using a tachymetric feedback which, since we have adopted the logarithmic scale, takes the form:

$$\frac{l}{n}\frac{dn}{dt}$$

The control signal for the rod drive motors finally will be of the form:

$$A\,(\log n_0 - \log n) - B.\frac{l}{n}\frac{dn}{dt}$$

The $\log n$ and $\frac{l}{n}\frac{dn}{dt}$ signals, which are not supplied naturally by the reactor, must be computed. The fact that $\log n$ and its derivative are needed simultaneously suggests the use of a method, now conventional, where analogs are used, namely deducing $\log n$ from its derivative by l integration and not $\frac{l}{n}\frac{dn}{dt}$ from $\log n$ by a derivation which, theoretically, makes it possible to compute n without any error in the speed.

Simple but Accurate

By noting that rod motion is the main cause of disturbance in this logarithmic derivative computation, it will be seen that the fact of setting in *a priori* the information bearing on this motion provides means of improving its precision.

This leads to building a true, but highly simplified, simulator of the reactor operation.

It is of interest to note here that the anticipation-loop bearing on the rod movements acts in the stabilization of the system by introducing the equivalent of a positional control of the bars.

It will be seen that the schematic of the control loop of MELUSINE is relatively complicated. For TRITON, we obtained a simpler design by applying the most popular method for the regulation of common integrators: the controlling datum is the position of the rod.

Satisfactory Difference

Since we do not insert a second integrator into the loop, it is stable in itself, and the computation of the logarithmic derivative is no longer necessary for stabilization.

The rod control signal is of the form $\frac{n_0 - n}{n_0}$, division by n_0 being obviously intended to maintain a constant gain in the loop.

Rod motion or displacement is made proportional to this relative difference. A gain of 7 to 8 pcm per percentage point of difference is satisfactory.

The rate of motion of the control rods of this type of reactor is commonly limited for safety reasons; positional control indicates that the rod displacement should be rather limited, which makes it possible to achieve better regulation. This means limiting the reactivity instead of its derivative.

We have particularly endeavoured to describe two main trends in our efforts; one toward the use of techniques which have already been tested elsewhere in conventional areas; and the other toward the concentration inside the swimming pool of elements which may be active.

We know we can go much further in these two realms, which we believe to show promise. We can achieve other concentrations and introduce other conventional techniques such as the use of correction networks. The static precision of automatic power regulation could possibly be greatly improved by a low-pass correction network.

This article is a translation of a paper presented by J. Sauvinet, C. Samuel and A. Virnot, of the Societe INDATOM, at the Conference on the Peaceful Uses of Atomic Energy held at Geneva, 1958.

accent on

Research and Development

Evidence of the out-of-the-ordinary service that Keith Blackman render to industry and commerce in their need for fan engineering equipment is the accent placed on Research and Development. This exclusive service includes the use of laboratories specifically equipped for research into

axial and propeller fan design
centrifugal fan design
dust and air filtration
acoustics
metallurgy

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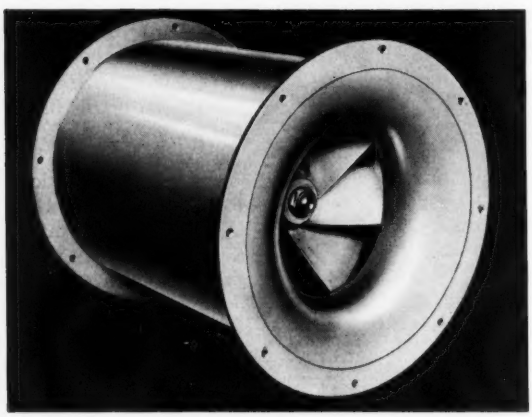
The Ax-Cent Fan



A tangible result of the Keith Blackman service is the new AX-CENT COMPOUND FLOW FAN — Provisional Patent No. 3148/58. Externally similar to the conventional axial fan, the AX-CENT fan offers:

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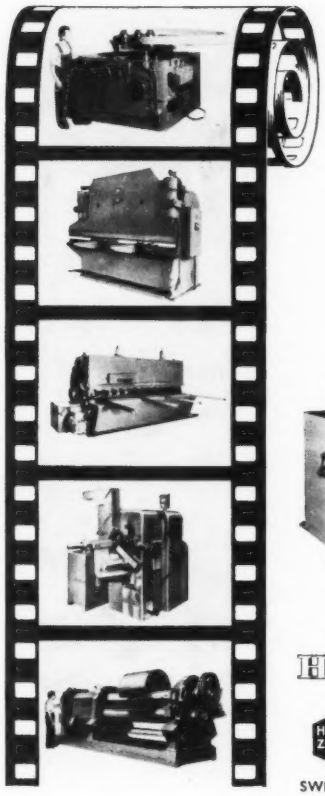

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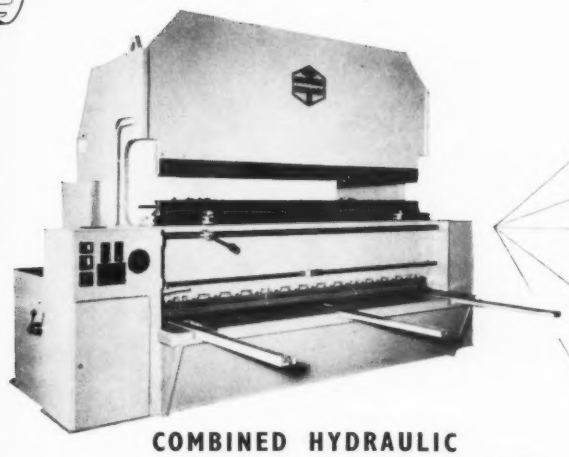

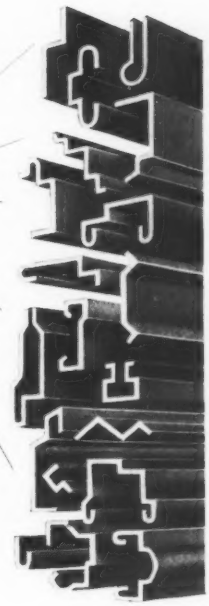

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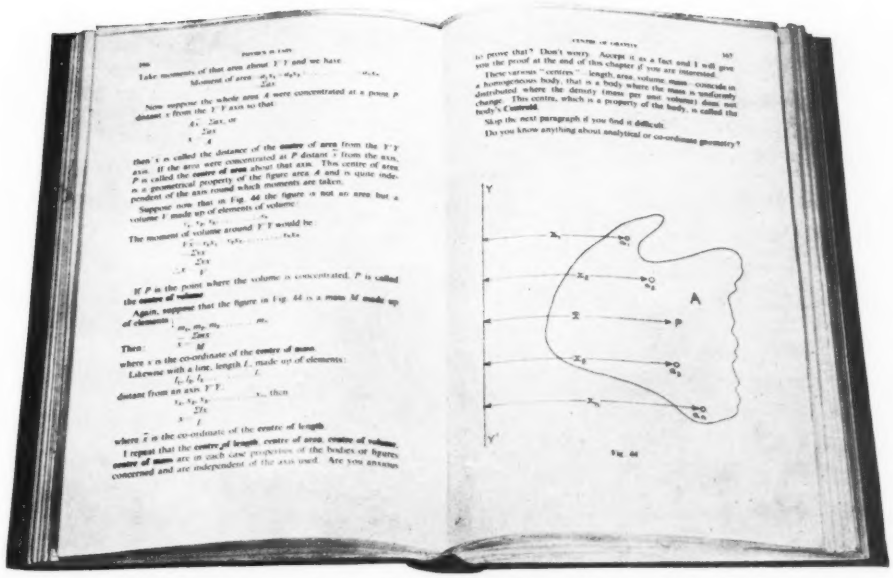

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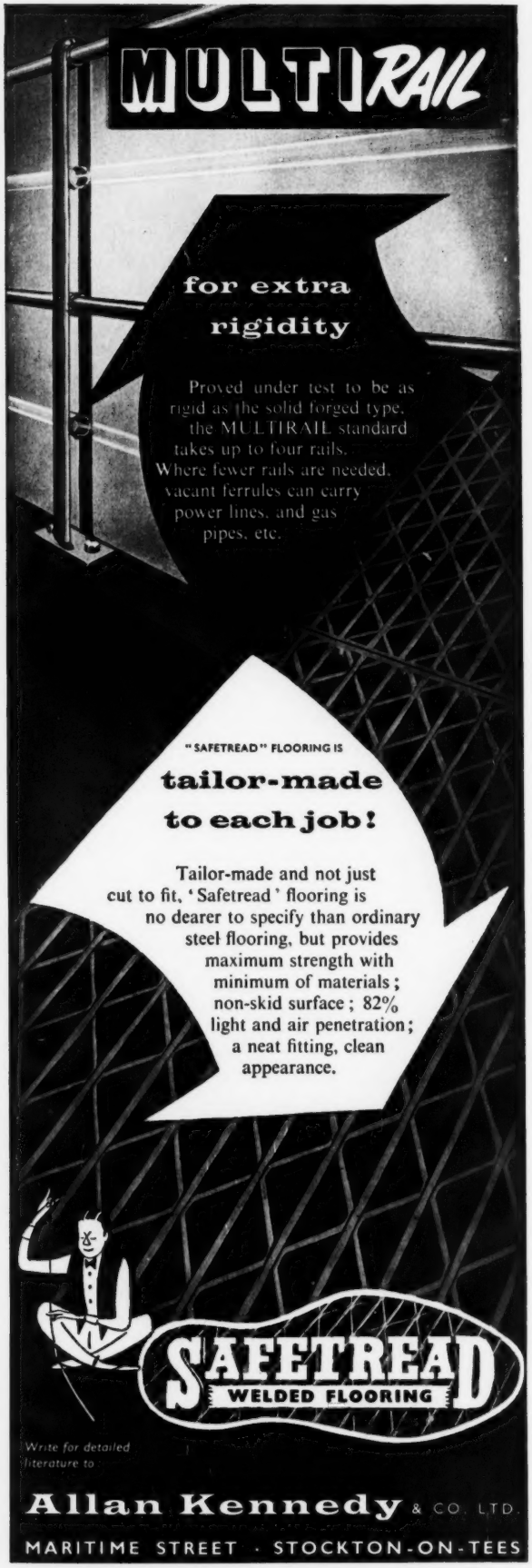
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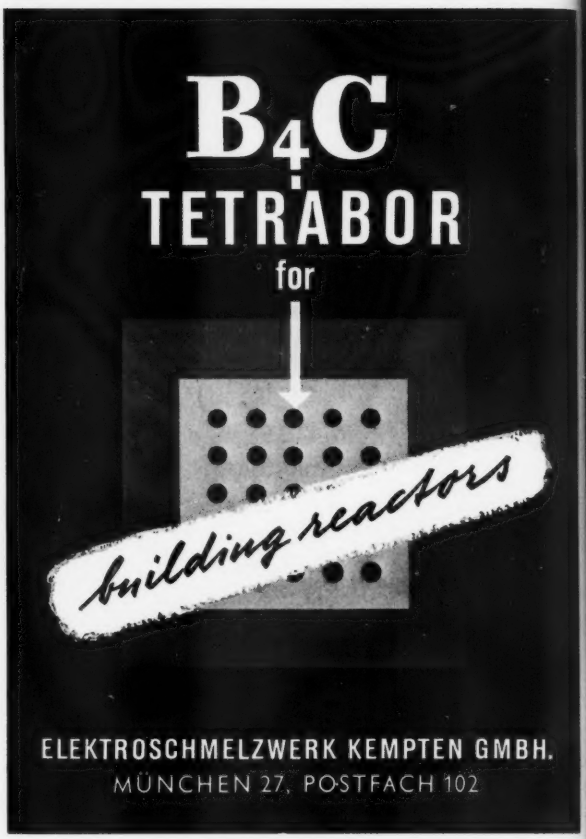

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